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May 1998

US Army Corps of Engineers
Waterways Experiment Station

Geological-Seismological Evaluation of Earthquake Hazards at St. Stephen Powerhouse, Cooper River Rediversion Project, South Carolina, and Newmark-Sliding-Block Type Deformation Analysis of Embankments

by Ellis L. Krinitzsky, Mary E. Hynes, Donald E. Yule, Richard S. Olsen

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Prepared for U.S. Army Engineer District, Charleston

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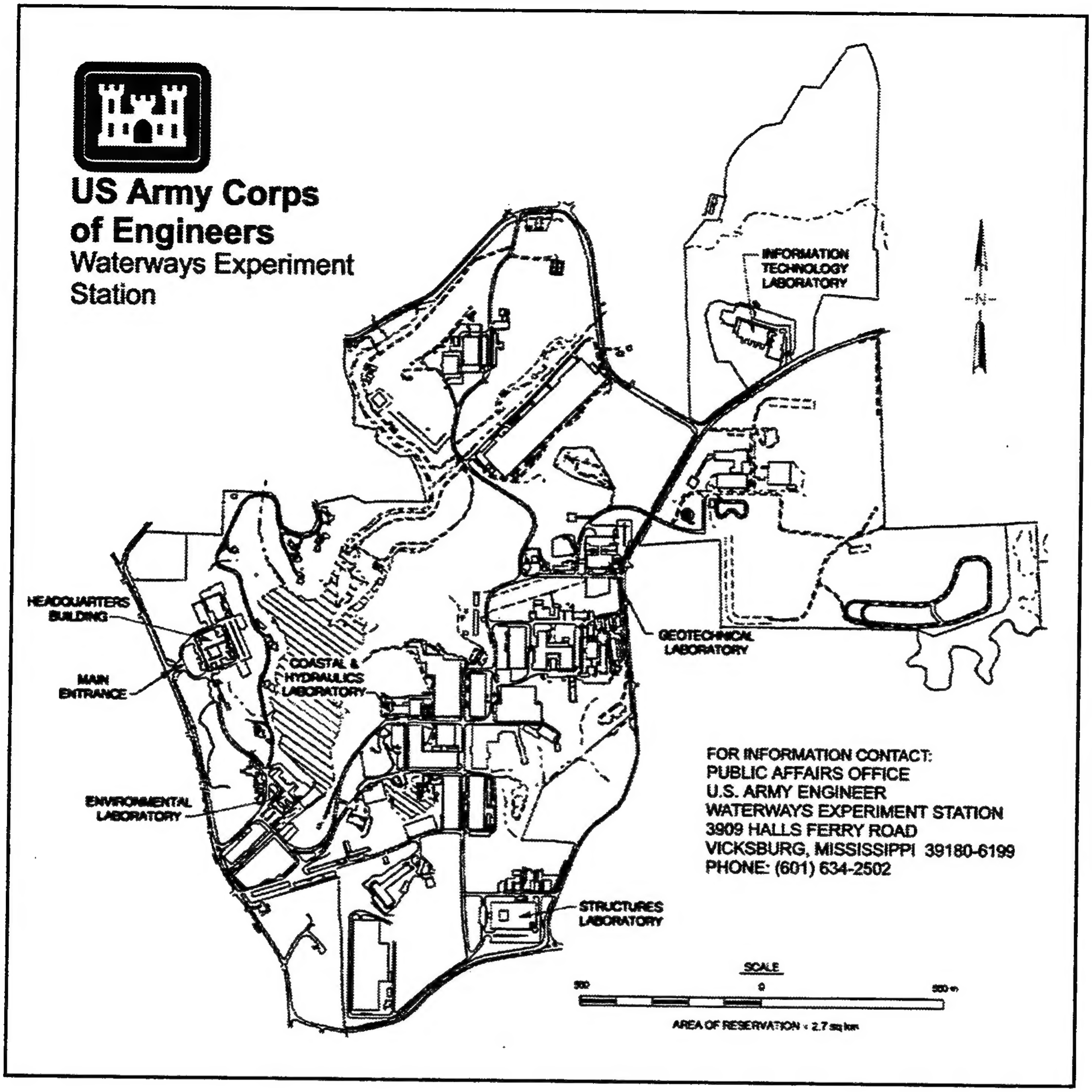

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Contents

Preface

This report summarizes a study conducted by the U.S. Army Engineer Waterways Experiment Station (WES) for the U.S. Army Engineer District, Charleston, SC (CESAC). The CESAC Project Manager was Mr. Wayne Bieganousky, Chief, Geotechnical, Materials, Sitework and Navigation Section (CESAC-EN-DF).

Dr. Ellis L. Krinitzsky, Geotechnical Laboratory (GL), and Mr. Donald E. Yule, Earthquake Engineering and Geophysics Branch (EEGB), Earthquake Engineering and Geosciences Division (EEGD), GL, conducted the portion of the study regarding seismic hazard. Dr. Mary E. Hynes, Chief, EEGB, Dr. Richard S. Olsen, EEGB, and Mr. Yule conducted the portion of the study regarding displacement analyses. Mr. Joseph B. Dunbar, Engineering Geology Branch (EGB), EEGD, GL, assisted the project considerably by collecting background information about the project, construction and design records, and regional geological and seismicity information.

Overall direction at WES was provided by Dr. Lillian D. Wakeley, Acting Chief, EEGD, and Dr. William F. Marcuson III, Director, GL.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
inches	2.540	centimeters
miles (U.S. statute)	1.609344	kilometers
pounds	0.4535924	kilograms, assuming G=980.665 cm/sec^2
pounds	4.4481	Newtons
pounds (force) per square inch	175.1	Newtons per square meter
pounds (force) per square inch	6.8947	kiloPascals
tons per square foot	95.8	kiloPascals
atmospheric pressure	1.0332	kilograms per square centimeter, assuming G=980.665 cm/sec^2
atmospheric pressure	101.325	kiloPascals

Note: 1 atm = 14.696 psi = 1.0581 tsf = 1 ksc = 100 kPa

1 Introduction

At the request of the U.S. Army Engineer District, Charleston, the U.S. Army Engineer Waterways Experiment Station conducted an evaluation of the geological-seismological hazard at the St. Stephen Powerhouse Project, which is part of the Cooper River Rediversion Project in South Carolina. The project is located about 60 km north of Charleston, SC, and consists of a reinforced concrete powerhouse structure founded on rock, flanked by rolled-fill earth embankments, founded partially on rock and partially on alluvium. For the purposes of this study, the alluvium is assumed to be competent, not susceptible to liquefaction.

Executive Summary

The Maximum Credible Earthquake (MCE) is estimated to correspond to a magnitude 7.5 event, 55 km from the site, resulting in peak ground accelerations at the site of 0.32 to 0.35 g. The Operating Basis Earthquake (OBE) is estimated to correspond to about a magnitude 5 event, resulting in a peak ground acceleration of 0.04 to 0.05 g at the site. The Newmark-sliding-block analyses indicate deformations in the maximum section under the MCE will be negligible, less than 1 cm. However, deformations under retaining walls and embankments founded on natural ground may be on the order of 15 to 35 cm.

Purpose and Scope

The purpose and scope of this study are as follows:

a. Determine rock outcrop ground motions appropriate for seismic analysis of embankment dam and reinforced concrete control structures, to include peak ground motion parameters, recommended analogous accelerograms, and response spectra.

b. Provide these recommendations in a letter report, to include the basis for selection of these motions, historical seismicity of the area, identified seismic source zones and hot spots, and basis for attenuating these motions to the site.

c. Since this is a low hazard dam with high consequences of failure, provide ground motions ranging from MCE motions to standard OBE motions

(corresponding to a return period of 144 years as recommended in ER 1110-2-1806).

d. WES personnel visited the Charleston District to collect background information about the site and dam structures necessary for the selection of ground motions and as needed for a preliminary deformation analysis of the embankment structure.

e. Conduct preliminary seismic response and deformation analysis of the embankment, and include in the report. It is assumed that sufficient information is available from design memoranda to estimate input parameters for the embankment deformation analysis.

f. An evaluation of liquefaction potential is beyond the scope of this study.

Organization of Report

The earthquake ground motions, ranging from MCE to OBE, are provided in Chapter 2 with the basis for selecting these motions. Chapter 3 contains the results of the Newmark-sliding-block analyses. References, Tables, and Figures follow the text. Appendix A contains a detailed listing of the seismic history of the project area.

2 Geological-Seismological Evaluation of Earthquake Hazard

Background

Purpose and Scope

The purpose of the geological-seismological investigation is to evaluate the earthquake hazards at the St. Stephen Powerhouse site. The objective is to provide ground motion parameters, response spectra, and analogous accelerograms for the earthquake ground motions that would be felt in the free field at the site. The ground motions defined by this study are for use in the engineering evaluation of the embankments and reinforced-concrete structures.

This study consists of both a geological and a seismological analysis and includes the following: (a) a geological appraisal of the tectonics and the potentials for activity in the region, (b) a seismological appraisal of the historic seismicity, (c) an interpretation of seismic source areas and MCE with their prospects for recurrence, (d) attenuated peak ground motions at the site, and (e) accelerograms and response spectra for analogous cyclic shaking. The ground motions presented are in accordance with the requirements mandated by ER 1110-2-1806 of 31 July 1995.

Study Area

The study includes the geology, seismic tectonics, and earthquake potential within a radial distance of 150 km of the powerhouse.

Geology and Tectonics

The St. Stephen Powerhouse is in the Atlantic Coastal Plain about 60 km north of Charleston. Figure 1, from Klitgord, Dillon, and Popenoe (1983), shows schematically the geology of the region. The fall line separates the Coastal Plain from the ancient metamorphosed rocks of the Piedmont. There are two basement hinge zones. The hinge zone at the fall line is where the ancient

metamorphosed and crystalline rocks dip seaward and are overlain by the younger sedimentary deposits that comprise the Coastal Plain. Another hinge line at the edge of the Continental Shelf is where the dip steepens into the ocean and where the Coastal Plain is terminated.

The buried metamorphosed rocks beneath the sediments of the Coastal Plain show magnetic highs and magnetic lows. The ancient rocks contain the remnants of basins that resulted from late Triassic rifting. These show up as magnetic lows. Intrusive igneous rocks, which may be ancient, show up as magnetic highs. These heterogeneities beneath the blanket of Coastal Plain sediments may be responsible for concentrating stresses, the release of which causes fault displacements that extend into the overlying deposits and are locally the cause of earthquakes.

Shilt et al. (1983) ran reflection profiles through the Coastal Plain sedimentary layers. A probable boundary between lower Mesozoic sediments and crystalline basement or an older basalt is formed at about 1,400 m in the Charleston area. The profiles contain displacements that indicate faulting within the sedimentary section. The thickness of sedimentary rocks at the St. Stephen Powerhouse site is slightly less than that in the Charleston area, or about 1,000 m.

Foundation Lithology

The Powerhouse is in an area of the Coastal Plain where the surficial deposits are alluvial terraces and alluvium deposited in river valleys. Thicknesses of those deposits were determined by borings at the site and were found to be in the range of 80 to 100 ft. Preconstruction borings (Design Memorandum 6, 1975-1978) show a good correlation of materials from boring to boring throughout the site. Typically the section is composed of bedded sands and silts with interspersed clays and occasional lenses which contain crushed shells.

The bedrock sequence beneath the Powerhouse, as revealed by borings (Design Memorandum 6) is:

a. Indurated clay shale, about 15- to 20-ft thick.

b. A glauconite zone about 1/2-ft thick.

c. Fossiliferous limestone or coquina, about 15-ft thick, (with the above glauconite zone, this is the bearing level for the Powerhouse).

d. Thin sand layer, slightly calcareous and partially indurated about 5- to 10-ft thick.

e. Limestone, about 25- to 30-ft thick. The limestone is a highly fossiliferous coquina through most of its thickness. The coquina is highly porous and is believed to be the main water-producing stratum in the section. The water is artesian.

f. Sand, about 20-ft thick, slightly calcareous, and irregularly indurated. The lower 5 ft is shaley and grades into the underlying layer.

g. Soft to medium hard, calcareous shale. The shale forms an aquiclude for the aquifer lying above. This shale is similar to the upper shale.

These sedimentary beds are generally flat-lying and are correlatable between borings. No fault displacements or other structural anomalies were observed in the borings and excavations made at the site.

Seismicity

Seismic History

A tabulation of earthquakes of Modified Mercalli (MM) intensity III and greater, recorded within 150 km of the St. Stephen Powerhouse, is shown in Appendix A. The data are from the National Geophysical Data Center of the National Oceanic and Atmospheric Agency in Boulder, CO. The years of coverage are from 1698 to 1993. Figure 2 shows the geographic distribution of these earthquakes. The location of the St. Stephen Powerhouse is indicated by a star. No earthquakes are shown within a radius of about 45 km from the Powerhouse. The principal source area of seismicity is a relatively small area of intense seismicity to the southwest of the Powerhouse. Another lesser and more diffused source lies to the west of the Powerhouse.

The earthquake information for this region prior to the 1960's was recorded as "intensity" which is a measure of how an earthquake is felt and the damage it does. The scale used is the MM of 1931, shown in an abbreviated form in Table 1. The scale is a subjective numerical index that ranges from I to XII. Intensity XII, or total destruction, is conceptual but almost never occurs.

Earthquake magnitudes are indirect measures of the energies released during earthquakes. The general relation between intensity and magnitude for a plate interior is shown in Table 2.

Earthquakes in this region can be inferred to result from one or more of the following possible causes.

a. Focusing of regional compressive stresses along the boundaries of heterogeneous rock masses and release of these stresses by movement through reactivation of ancient faults.

b. Possible small-scale introduction of magma from great depth with an accompanying buildup of stresses.

c. Focusing and release of regional stresses along ancient rifts which remain as zones of crustal weakness.

d. Slow, very broad regional compression causing reactivation of ancient thrust faults.

e. Extensional movement along a sagging graben with activation of normal faults.

There is no way that all of these theories can apply everywhere since the extensional and the compressional postulations contradict each other. Also, each of these theories can be interpreted as meaning that a major earthquake can happen at a location where no historic earthquake has occurred. That idea, though seemingly possible on the face of it, must be handled with care because it can mean that larger earthquakes will happen almost everywhere in this region and that is not what we observe elsewhere in the world. It is essential to concentrate on the experiences with earthquakes as the only direct clue to present-day tectonics. Earthquake- generating faults are not identifiable on the ground surface in the region. However, the areal distribution of earthquakes and their concentrations can be used to define locations and boundaries for seismic source zones.

Seismic Source Zones and Maximum Earthquakes

A seismic source zone is an inclusive area over which an earthquake of a given maximum size can occur anywhere. That earthquake is a floating earthquake. A seismic zone is supplemental to and can include faults that are the sources of earthquakes when they are identified. The purpose of such zones is to avoid surprises.

The seismic zones as constructed in this report represent present-day tectonism. These are zones that are not determined by tectonic and physiographic provinces or regional geologic structure since those are products of past tectonism.

Criteria for developing zonations are:

a. Zones that have great activity should be as small as possible. They are likely to be caused by a definite structure, such as a fault or a pluton, and activity should be limited to that structural association. Such a source may be a <u>seismic hotspot</u>. A seismic hotspot requires locally large historic earthquakes, frequent to continuous microearthquakes, and a well defined area. Maps of residual values for magnetometer and

Bouguer gravity surveys may provide structural information to corroborate the boundaries of hotspots.

b. One earthquake can adjust a boundary to a seismic zone, but cannot create a zone.

c. The maximum felt earthquake is equal to or less than the maximum zone earthquake.

d. The maximum zone earthquake is a floating earthquake, one that can be moved anywhere in that zone.

e. Assignment of the maximum zone earthquake is judgmental.

Figure 3 shows seismic zones with MM intensity values for maximum floating earthquakes. These are zones for potential earthquakes.

The severest seismic hazard is concentrated in two small seismic source zones at Summerville and Bowman. Summerville is given a peak intensity of IX to X based on the 1886 experience. Bowman has similar seismicity, but the earthquakes are much fewer and more restricted in area, thus a lower potential of VIII is assigned. The much broader and more encompassing zone that includes Columbia and Greenville includes widely scattered small earthquakes. The largest are $M = 4.5$-4.9. An earthquake of this size indicates a peak epicentral intensity of V to VI. The VI was raised to VII for conservatism. The adjacent zones are very nearly aseismic. However, as small earthquakes are known to occur even in the most aseismic areas, a base seismicity of VI is assigned. The VI is a level at which there is hardly any damage.

Figure 4, from Tarr and Rhea (1983), shows in greater detail the evidence for identifying and locating the heightened seismic potential at Summerville and Bowman. Note the interpretations for the seismicity at Summerville, Middleton Place, and Adams Run. The elongate ellipses represent interpretations of the fault zones along which the earthquakes are occurring. The interpretations are from fault-plane solutions made on microearthquakes, those that are $M \leq 3.5$, recorded between March 1973 and December 1979. The exercise was to more accurately locate the source area for the Charleston earthquakes.

Tarr and Rhea (1983) believe that the observed activity in the Summerville - Middleton Place source area identifies the proper location of the Charleston earthquakes of 1886. They found a three-segment fault zone. The faults strike northwest and are steeply dipping at angles of 80° to 90°. The interpretation is that these are dip-slip motions. Events at Bowman and Adams Run are spatially distinct. No earthquakes were recorded in the gaps between these sources in 9 years of observations following 1971. The depths and intense clustering of the earthquakes indicate planes of weakness in crustal units of Mesozoic age.

The vertical sections in Figure 4 show that the earthquakes have focal depths to about 15 km and are broadly scattered in the vertical sections. These are earthquakes that reach far into the crystalline basement rocks where stress drops can be large enough to produce powerful earthquakes.

Appendix A shows that dozens of felt earthquakes occurred along with the Charleston event of 1886. There would have been thousands of micro-earthquakes shown had there been recordings made. Those earthquakes are still occurring, as shown in the work of Tarr and Rhea (1983). This meets the criteria for a seismic hotspot.

Appendix A lists four Charleston earthquakes of 1886 that range from VI to X. These are shown in Table 3 along with approximate coordinates for their epicenters.

In the isoseismal map shown in Figure 5, Bollinger (1977) reinterpreted the reports of ground shaking in 1886. His interpretation for the St. Stephen site is approximately an intensity VIII. This value can be corroborated by attenuating the intensity over the distance from the source to the site. A general distance, which can only be approximate for an intensity value, is given in Appendix A as 57 km. A rate of attenuation for the Eastern Province is given by Chandra (1979). Figure 6 shows this attenuation to be 1-1/2 intensity units. The intensity at the Powerhouse would be an MM 8.5.

Bollinger (1983) determined that the intensity data showed the 1 September 1886 Charleston earthquake to an $m_b = 6.7$. Table 2 shows this to be an $M = 7.5$. This magnitude value allows a determination to be made for magnitude-and-distance attenuations. These will be presented in this report under ground motions.

Table 3 shows that 11 historic earthquakes were felt at the St. Stephen Powerhouse site with intensities of IV and greater. Significantly, nine of these events came from the Summerville area. The 3 August 1959 earthquake came from a different source in the region. That earthquake was an intensity VI and it originated in the same intensity VI zone in which the Powerhouse is located. An intensity of MM VI was estimated by Stearns and Wilson (1972) for the effects in the area of the site of shaking from the major New Madrid event, around 800 km distant. The only serious shaking came from the 1 September 1886 Charleston earthquake and was an MM intensity of 8.5 at the site.

Earthquake Ground Motions

Maximum Credible Earthquake (MCE)

The MCE is the largest earthquake that can reasonably be expected. ER 1110-2-1806 (31 July 1995) mandates that for a critical structure MCE be

obtained by a deterministic analysis. The deterministic analysis is not time-dependent, as is a probabilistic evaluation.

For the St. Stephen Powerhouse, MCEs would be as follows:

a. An MM intensity X earthquake, M = 7.5, attenuated from the Summerville source for ~ 55 km to the site (see Figure 3).

b. A floating earthquake of MM VI, M = 5.0.

Field Conditions

Ground motions from an earthquake source using MM intensity are characterized as being either near field or far field. Ground motions are different for each field type. Near field motions, those originating near the earthquake source, are characterized by a large dispersion in the peak ground motions which are caused by complicated reflection and refraction patterns, focusing effects of the waves, impedance mismatches, and resonance effects. In contrast, the wave patterns for far field motions are more orderly and they are more muted or dampened so that they are better predictable.

The limits of the near field are variable, depending on the severity of the earthquakes. The relationship between earthquake magnitude (M), epicentral intensity, and the limits of the near field are given in the following set of relations, see Krinitzsky (1995).

Near Field Limits		
M	MM Maximum Intensity, Io	Distance from Source, km
5.0	VI	5
5.5	VII	15
6.0	VIII	25
6.5	IX	35
7.0	X	40
7.5	X-XI	45

Near field conditions are specified only when the site of interest is located within or near a seismic hotspot.

Though the Summerville source is a hotspot, its distance from the site requires the use of far field motions for the attenuated intensity level. A mean plus standard deviation (SD) is used to encompass the range of strong motion values and to provide a practical level for engineering.

For the floating earthquake of MM VI in the zone of the St. Stephen Powerhouse, a far field set of motions would be used. The principle is that the earthquake, even if it were to happen at the site, would be at a focal depth at or greater than the near field limit for a MM VI.

Table 4 gives parameters for peak MCE ground motions in the free field at the St. Stephen Powerhouse site. The parameters are for selecting and adjusting strong motion records to use in engineering analyses. The ground motions were obtained from intensity-based charts (Krinitzsky 1995) and magnitude-distance charts (Krinitzsky 1995). The intensity charts are shown for acceleration, velocity, and duration for hard sites in Figures 7 to 9 and for soft sites in Figures 10 to 12. Ground motion charts for magnitude and distance for hard sites are shown in Figures 13 to 15. Soft sites are shown in Figures 16 to 18.

A site is soft when it has a surface layer ≥ 16 m, in which the shear wave velocities are less than 400 m/sec. A hard site is where the shear wave velocities are greater than 400 m/sec and overlying soft layers with smaller shear wave velocities are less than or equal to 15 m in thickness.

The earthquakes in South Carolina are interpreted to be shallow crustal events for which the focal depths are ≤ 19 km.

MCE Analogous Time Histories

The charts in Figures 7-18 show peak values and catalogue numbers for selected strong motion records. The catalogue is by Leeds (1992) and is a collection of recommended accelerograms and response spectra. Figures 19 to 30 show a selection of records that can be used. They are:

Figure 19. San Fernando Earthquake, 9 February 1971, 535 S. Fermont AV., Basement, CAL 61.

Figure 20. Superstition Mountain, 15 October 1979, CAL 139.

Figure 21. Coalinga, 2 May 1983, Parkfield Fault Zone 14, 90 Deg CAL 189.

Figure 22. Coalinga, 2 May 2 1983, Parkfield Fault Zone 14, 0 Deg, CAL 190.

Figure 23. Santa Cruz Mountains, Loma Prieta, 17 October 1989, San Francisco International Airport, CAL 391.

Figure 24. Morgan Hill Earthquake, 24 April 1984, Gilroy No. 7, CAL 216.

Figure 25. Morgan Hill Earthquake 24 April 1984, Coyote Lake Dam, CHN-1, 285 Deg, CAL 228.

Figure 26. Morgan Hill Earthquake, 24 April 1984, Coyote Lake Dam, CHN-3, 195 Deg, CAL 229.

Figure 27. Whittier Earthquake, 1 October 1987, Tarzana, Cedar Hill Nursery, CHN 1, 90 Deg, CAL 270.

Figure 28. Whittier Earthquake, 1 October 1987, Tarzana, Cedar Hill Nursery, CHN-3, 0 Deg, CAL 271.

Figure 29. Sturno, Italy, 23 November 1980, N-S Component, ITA 20.

Figure 30. Sturno, Italy, 23 November 1980, E-W Component, ITA 21.

All of the records are for hard sites except those in Figures 19 and 20, which are for soft sites. Additional hard site records were extracted from the USGS database of strong ground motion recordings to find records that best fit the target ratio of peak ground acceleration (PGA) and peak ground velocity (PGV), magnitude, distance, and response spectra (described in the next section). The records considered are listed in Table 5. Among these records, three appeared to be particularly promising because of the PGA to PGV ratio:

1. Loma Prieta Gilroy #7, 0 degree component.
2. Coalinga Earthquake, Parkfield Fault Zone 14.
3. San Fernando Earthquake, 234 Figuero.

The acceleration histories and Arias intensities for these records are shown in Figures 31, 32, and 33, respectively. Duration of strong motion is shown in two forms on these figures:

1. The duration of motion exceeding 0.05 g.
2. The duration of Arias intensity from 5 to 95% of total energy

By both duration definitions, the three records have durations ranging from 11 sec to 18 sec, which is reasonably consistent with the target duration for a hard site. The Loma Prieta and Coalinga records are from $M = 6.5$ events, somewhat less than the target MCE magnitude of 7.5. This is reflected in the total Arias intensity delivered during the period of strong motion and total energy. The Loma Prieta Gilroy # 7 record has total Arias intensity of 101 cm/sec, with 91 cm/sec delivered in the duration of strong motion (defined as 5 to 95% of total energy delivered) of 11.5 sec. The Coalinga Fault Zone 14 record has 67 cm/sec total Arias intensity with 56 cm/sec delivered in a duration of 13.38 sec. The San Fernando Gilroy # 7 record has 73 cm/sec total Arias intensity with 65 delivered in a duration of 11.3 sec.

MCE Response Spectra

The response spectra for the MCE was estimated from spectral attenuations developed for Eastern North America, specifically Atkinson and Boore (1995) and Toro, Abrahamson, and Schneider (1997), using the sources zones described earlier. The Toro-Abrahamson spectra generally exceed the Atkinson and Boore spectra at periods exceeding 0.1 sec, and are recommended for the MCE response spectra. Figure 34 shows the Toro-Abrahamson spectra for damping ratios of 2, 5, 10, and 15%. Figures 35, 36, and 37 show the mean and mean-plus-sigma response spectra from these two relationships for a damping of 5%, with the response spectra of the three acceleration histories superimposed, Loma Prieta record in Figure 35, Coalinga record in Figure 36, and San Fernando record in Figure 37. All three records have high energy content in the period range of about 0.1 sec to 2 sec, and generally trace the target mean-plus-sigma response spectra.

Operating Basis Earthquake (OBE)

The OBE is an earthquake that allows damage, providing there is no hazard to human life, and permits the structure to remain operational with repairs. Further, it is an earthquake that is expected to occur during the life of the structure. According to ER 111-2-1806, the OBE may be determined either deterministically or probabilistically. The actual values of the OBE motions are based on economic considerations, but typically they correspond to ground motions with a return period of exceedance of about 144 years. For this study, the OBE ground motions were selected from the USGS maps (dated November 1996) available over the Internet. These maps provide detailed probabilistic seismic hazard information on the resolution of 0.1 degree latitude by 0.1 degree longitude for return periods of 475, 975, and 2,475 years. The USGS maps provide peak ground acceleration (PGA) for various site conditions as well as equal hazard spectral ordinates (SA) for periods of 0.2, 0.3, and 1.0 sec. Earthquake Design Guidance for Structures (EDGS), Developing Standard Response Spectra and Effective Peak Ground Accelerations for Use in the Design of Civil Works Projects, dated October 1996, recommends extrapolating the data on a log-log plot to estimate spectral ordinates and PGA for other return periods. The resulting seismic hazard curves are shown in Figure 38 and listed in Table 6. Since the points are generally not colinear on a log-log plot, extrapolation using all three return periods is slightly different from using only the nearest two data points. These two extrapolations are shown in Figure 38, and result in the range of values listed in Table 6.

USGS-National Seismic Hazards Mapping Project-Deaggregated Seismic Hazard

Extracted from National Hazard Mapping Project, USGS www home page:

> At 56 cities in the Central and Eastern U.S. (CEUS) and 44 cities in the Western U.S. (WUS), the seismic hazard corresponding to a 2% probability of exceedance in 50 years is deaggregated by magnitude (Mw, or moment magnitude) and by epicentral distance (CEUS) or hypocentral distance (WUS). Hazard with respect to magnitude is binned into intervals of width 0.5 Mw. Hazard with respect to epicentral distance is binned into intervals of 25 km width. The hazard probabilities are deaggregated for the following ground motion parameters: PGA, 1.0, 0.3, and 0.2 second PSA (Note: This corresponds to PGA in text.).
>
> Four matrices of percent contribution to hazard are available at this web site. The matrices are organized with magnitude intervals corresponding to columns and distance intervals corresponding to rows. The first row of numbers gives the upper endpoint of the magnitude interval. For example, the number 6 means that seismic sources with magnitudes in the interval 5.5< Mw <= 6.0 are included in hazard calculations for that column. The first column of numbers gives the upper endpoint of the epicentral distance interval. For example, the number 150 means that source-to-station distances in the interval 125 < d <= 150 km are included in the hazard calculations for that row. Missing rows, or gaps in the matrix, correspond to distance ranges for which the greatest percent contribution to hazard is less than 0.0005, yielding a row of zeros to the level of precision given in the below data.
>
> For the CEUS, the lowest magnitude considered for hazard calculations is MbLg 5.0. This magnitude corresponds to Mw = 4.7 using the Johnston (1996) relationship between the two magnitudes. Thus, for CEUS cities, the interval width for the first column of contribution to hazard is about 0.3 Mw units, rather than 0.5 units, the usual interval width. For the WUS, the lowest magnitude considered for hazard calculations is Mw = 5.0. The entries are percent contribution to hazard. They will sum to 100 percent for each matrix.

The deaggregated matrices for Charleston, SC, are provided in Table 7 for PGA and SA at 1, 3.33, and 5 Hz (periods of 1, 0.3, and 0.2 sec), for a return period of 2,475 years. Examination of the table indicates that the majority of seismic hazard comes from nearby zones, within 25 to 50 km, as expected from the seismic history, and as identified earlier in this chapter. The deaggregated

matrices are plotted in Figure 39 for PGA and Figures 40-42 for the spectral ordinates.

Previous Interpretation of Ground Motions

Previous interpretations of ground motion parameters for use at the Cooper River Rediversion Project, of which the St. Stephen Powerhouse is a part, are as follows:

a. In a letter of 22 December 1981 to Mr. Harry E. Thomas, FERC, Washington, DC, from Otto W. Nuttli, H. Bolton Seed, and Stanley D. Wilson, the following reasonings were presented:

    (1) A Charleston, SC, earthquake was postulated at a distance of 65 km. MM intensities of IX to X should be constant to 25 km and fall off to IX at 45 km.

    (2) The design motions should be for a Charleston earthquake, M = 7, 15 mi from the Pinopolis West Dam. (The Pinopolis West Dam is about 10 km from the St. Stephen Powerhouse.)

    (3) Peak acceleration at the site is 0.30 to 0.35 g.

b. In a meeting with FERC on 2 September 1982 in Washington, DC, re the Santee North and Pinopolis West Dams, the following values were recommended:

    (1) A magnitude at the source of 7.5.

    (2) Acceleration = 0.45g. Motion for a rock outcrop near the dam. Duration = 25 sec (≥ 0.05g).

c. In a report of 10 June 1986 to Mr. Ronald A. Corso, FERC, Washington, DC, from Dr. A. J. Hendron, Jr., the following recommendation was made for the Pinopolis West Dam:

    (1) Acceleration = 0.45 g,
    Velocity = 22 in./sec

    The reasoning for the values was that 1 g has a velocity of 48 in./sec; proportional scaling provided the above parameters.

    (2) Use the Taft and Castaic records. Both records have single high peaks of 0.45 g.

3 Newmark-Sliding-Block Type Deformation Analysis of Embankments

Background

A Newmark-sliding-block type of deformation analysis models the displacing part of an embankment as a rigid block sliding on an inclined plane (Newmark 1965). This type of analysis is appropriate for an embankment dam if the embankment and its foundation soils are not expected to suffer liquefaction or severe softening under cyclic loading due to earthquake shaking, as is the case assumed at the St. Stephen Powerhouse Project. Other contributions to a coherent procedure using the sliding block approach have been made by Taylor and Whitman (1952), Ambraseys and Sarma (1967), Sarma (1975, 1979), Goodman and Seed (1966), Makdisi and Seed (1977), Franklin and Chang (1977), Franklin and Hynes-Griffin (1981), and Hynes-Griffin and Franklin (1984).

Shearing resistance between the potential sliding mass and the underlying base is evaluated in terms of a yield acceleration, k_y, defined as the acceleration of the sliding mass that will reduce the factor of safety against sliding to unity, i.e., that will make sliding imminent. The value of k_y is expressed as a fraction of gravity (g) and is obtained through a traditional limit equilibrium slope stability analysis that applies the seismic load horizontally at the center of gravity of the sliding mass. Spencer's method (1967) in the computer program UTEXAS3™ (developed by Stephen G. Wright at the University of Texas at Austin), adapted for microcomputer use as documented by Edris and Wright (1992), was used in this study.

An analysis of the amplification response of the embankment is typically incorporated to account for amplified accelerations in the embankment. Amplifications were estimated from empirical observations of dynamic response of embankments (Harder 1991), SHAKE analyses, and charts developed by Makdisi and Seed (1977) from numerous finite element response analyses of embankment dams founded on rock.

Because the amplified accelerations vary over the height of the embankment, yield accelerations were determined for possible sliding masses whose bases lie at various elevations in the idealized sections, both upstream and downstream.

Displacement charts have been developed for Newmark-sliding-block models by Makdisi and Seed (1977) and Hynes-Griffin and Franklin (1984). The Makdisi and Seed displacement charts were used in this study since they include the effect of earthquake magnitude and frequency changes due to amplification in the embankment.

Sections Selected for Analysis

A plan of the project is shown in Figure 43. Three sections were considered in the deformation analysis: Section 1, estimated to be the most vulnerable embankment section founded on natural soil deposits; Section 2, estimated to be the most vulnerable upstream section through a retaining wall; and Section 3, the maximum section of the embankment dams flanking the Powerhouse structure. The locations of these sections are shown in Figure 43. Section 1, as idealized, is shown in Figure 44. Section 2, as idealized, is shown in Figure 45. Section 3, as idealized, is shown in Figure 46. The material properties for the zones shown in Figures 44-46 were derived from the existing project documentation and are listed in Table 8.

Yield Accelerations

Yield accelerations were computed with Spencer's method in UTEXAS3. The slip surfaces with minimum yield accelerations at a given elevation are shown in Figure 47 for Section 1, Figure 48 for Section 2, and Figure 49 for Section 3. The computed yield accelerations for these sections are shown in Figures 50-52. Also shown are the computed static factors of safety.

Dynamic Response

Makdisi and Seed (1977) developed charts for dynamic response of embankment dams founded on rock from numerous finite element response analyses. In these analyses, the earthquake-induced acceleration applied to the sliding mass is interpreted by summing the contributions from the elements along the potential sliding surface, as proposed by Chopra (1966). Figure 53 shows the Makdisi-Seed dynamic response chart, which gives the summed acceleration applied to the sliding surface, k_{max}, divided by the peak crest acceleration, u_{crest}, expressed for surfaces at different depths in the embankment, as a ratio of depth of sliding surface, y, to embankment height, h.

Use of the Makdisi-Seed response chart requires estimation of the crest acceleration. Harder (1991) collected empirical observations of crest to base or abutment accelerations and developed the upper-bound chart shown in Figure 54. The data from the U.S. Army Engineer Corps Strong Motion Instrument Program (SMIP) database for seismic response of Corps dams, current through 1996, have been added to this figure. For a base acceleration of about 0.33g as recommended in Chapter 2, the corresponding upper-bound crest acceleration is 0.64g.

The Makdisi-Seed chart was derived for embankments founded on rock. For embankments founded on soil deposits, it requires some estimation of appropriate effective embankment height and crest acceleration to use in estimating k_{max}. SHAKE analyses were also performed to estimate k_{max} and u_{crest}, using the Corps program WESHAKE. Although WESHAKE is a one-dimensional wave propagation code, it provides a fairly good approximation of the dynamic response at depth (error is typically greatest in the top 10 to 20% of height of the column (Elton, Shie, and Hadj-Hamou 1991), particularly for slip surfaces passing through natural materials. The WESHAKE results in this study were also used to estimate k_{max}. The WESHAKE columns and estimated shear wave velocity profiles are shown in Figure 55. Shear wave velocities were estimated from the WES shear wave velocity data base and Cone Penetrometer Test (CPT) data base using Standard Penetration Test (SPT) blowcounts reported in the project documentation. The accelerogram used in the computations was the Loma Prieta Gilroy # 7 record described in Chapter 2. The WESHAKE results, acceleration, cyclic shear stress, and cyclic shear strain plotted versus depth, are shown in Figures 56-59. The k_{max} values, estimated from both the Makdisi-Seed chart and the WESHAKE results, are shown in Figures 60-63.

<u>Section 1, embankment on natural ground</u>. The crest acceleration for the dike was estimated from the free-field WESHAKE analysis which indicates a base acceleration of about 0.5g. The corresponding crest acceleration is about 0.7g from Figure 54. This results in the k_{max} values shown in Figure 60, estimated from the Makdisi-Seed chart in Figure 53. The WESHAKE analysis of this section assumed a possible zone of low velocity in the natural materials. If such a zone exists, it is unlikely that such high levels of acceleration could be transmitted to the dike. Consequently, the displacements were calculated using k_{max} values from both the Makdisi-Seed approach as well as the WESHAKE values plotted in Figure 60.

<u>Section 2, upstream retaining wall</u>. The crest acceleration for the retaining wall section was estimated as 0.64g from Figure 54, with a base acceleration of 0.33g, observed in the WESHAKE analysis. The k_{max} values from both the Makdisi-Seed approach and the WESHAKE calculations are plotted in Figure 61. Since all the yield surfaces passed below the wall, below the effective height, a constant value of k_{max} at a depth of 72 ft from the Makdisi-Seed approach was used in the displacement calculations.

Section 3, maximum embankment section flanking Powerhouse, upstream surfaces. The WESHAKE and Makdisi-Seed estimates for k_{max} values are plotted in Figure 62. Two effective heights were used in estimating the Makdisi-Seed values, 115 ft corresponding to the height of the crest above the shale bedrock base, and 64 ft, an average height of embankment above intake and tailrace elevations.

Section 3, maximum embankment section flanking Powerhouse, downstream switchyard surfaces. The WESHAKE and Makdisi-Seed estimates for k_{max} values are plotted in Figure 63. Because the switchyard is a fairly large, level ground area, the ground surface acceleration from WESHAKE was used to estimate the crest acceleration for the Makdisi-Seed k_{max} values, hence the close agreement between both approaches to estimate k_{max}.

Deformation Estimates

The Makdisi-Seed deformation chart, shown in Figure 64, was developed specifically for embankment dams founded on rock, as is the case for the main flanking embankments at the St. Stephen Powerhouse Project. The Hynes-Franklin displacement chart (after Hynes-Griffin and Franklin 1984) is shown in Figure 65 for comparison. The upper-bound displacement curve in the Hynes-Franklin chart generally corresponds to magnitude 7.5 earthquakes, and falls slightly below the average of the magnitude 7.5 relationship in the Makdisi-Seed chart. This difference is due in part to the integration scheme used to develop the chart, as well as the fact that the Makdisi-Seed chart uses response accelerograms computed in FLUSH throughout the embankment, whereas the Hynes-Franklin chart is computed directly from the recorded accelerogram. Since the difference is greatest at small levels of displacement, the Makdisi-Seed chart was used in the displacement computations. The displacement results are plotted in Figures 66-68.

Section 1, embankment on natural ground. Deformations and yield surfaces for this section are plotted in Figure 66. The yield surfaces for the dike section all pass beneath the embankment through natural soil deposits. The properties of these materials were estimated from other locations at the site since no direct measurements were available in the documentation. With these estimated strengths, the largest deformation is estimated to be about 16 to 34 cm. Better information about the natural soils may significantly reduce these deformation estimates.

Section 2, upstream retaining wall. Deformations and yield surfaces for this section are plotted in Figure 67. The maximum displacement estimated was 20 cm for surfaces passing through select fill beneath the retaining wall.

Section 3, maximum embankment section flanking Powerhouse, upstream surfaces. The displacements for this section are plotted in Figure 68. For an effective height of 64 ft, the displacements are zero, since the yield accelerations

exceed the estimated k_{max} values. For an effective height of 115 ft, which should be conservative, the maximum displacement is less than 1 cm.

Section 3, maximum embankment section flanking Powerhouse, downstream switchyard surfaces. The displacements for this section are plotted in Figure 68. The yield acceleration for these surfaces all exceeded estimated k_{max} values. Consequently, displacements for this section are zero.

Damage Assessment

For Section 3, the maximum section for the embankments flanking the powerhouse, zero to negligible (less than 1 cm) permanent displacements are expected for the assumed material properties and input motions, using maximum crest accelerations from empirical response charts. For the other sections, the dike and the retaining wall, deformations on the order of 15 to 30 cm were calculated, again using fairly conservative estimates of response. Deformation levels on this order are generally assumed to be acceptable, with no threat to reservoir retention.

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Table 1 Abbreviated Modified Mercalli 1931 Intensity Scale	
I.	Not felt except by a very few under especially favorable conditions.
II.	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III.	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibration like passing of truck. Duration can be estimated.
IV.	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing automobiles rocked noticeably.
V.	Felt by nearly everyone; many awakened. Some dishes, windows, and other fragile items broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles and other tall objects sometimes noticed. Pendulum clocks may stop.
VI.	Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII.	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-build ordinary structure; considerable in poorly built or badly designed structures. Some chimneys broken. Noticed by persons driving automobiles.
VIII.	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse. Great damage in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving automobiles disturbed.
IX.	Damage considerable in specially designed structures; well-designed frame structures thrown out-of-plumb; damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
	(Continued)

Table 1 (Concluded)	
X.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed. Ground badly cracked. Railroad rails bent. Many landslides on river banks and steep slopes. Shifted sand and mud. Water splashed over banks of rivers and lakes.
XI.	Few structures remain standing. Unreinforced masonry structures are nearly totally destroyed. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Railroad rails bent greatly.
XII.	Damage total. Waves apparently seen on ground surfaces. Lines of sight and level appear visually distorted. Objects thrown upward into the air.

Table 2
Equivalences Between Magnitude Scales and Intensity (Magnitudes were Modified from Nuttli and Shieh (1987). From Krinitzsky (1995)

Plate Interior						
M	m_b	M_L*	M_S	M_W	M_0 (dyne-cm)	Epicentral Intensity MM
4.3	4.0	--	2.9	3.8	10^{21}	IV
4.8	4.5	--	3.4	4.1	10^{22}	V
5.1	5.0	--	4.4	4.8	10^{23}	VI
5.4	5.5	--	5.4	5.4	10^{24}	VII
6.4	6.0	--	6.4	6.1	10^{25}	VIII
7.4	6.5	--	7.4	6.8	10^{26}	IX-X
8.4	7.0	--	8.4	7.4	10^{27}	XI-XII

* M_L generally not used in plate interior.

Table 3
Modified Mercalli, $I_s \geq$ IV at the St. Stephen Powerhouse Site. Data from IGDA/NOAA and Visvanathan (1980)

Date of Earthquake	Coordinates		I_o	Distance from Site km	I_s
Dec 16, 1811	New Madrid, MO		XI-XII	800	IV*
Sep 1, 1886	32.9 N	80. W	X	57	VIII**
Sep 21, 1886	32.9	80	VI	57	IV
Oct 22, 1886	32.9	80	VII	57	V
Nov 5, 1886	32.9	80	VI	57	IV
June 12, 1912	32.9	80	VII***	57	V
Aug 3, 1959	33.	79.5	VI	61	IV
Mar 12, 1960	33.07	80.12	V	42	IV
Feb 3, 1972	33.31	80.58	V	44	IV
Nov 22, 1974	32.9	80.14	VI	60	IV
Sep 21, 1992	32.05	80.11	V	44	IV

* Stearns and Wilson (1972).
** Bollinger (1977).
*** Visvanathan (1980).

Table 4 Free Field Egk Ground Motions for MCE at St. Stephen Powerhouse, Cooper River Rediversion Project			
	Accel, cm/sec^2	Vel, cm/sec	Dur ≥ 0.05g, sec
I_o = X (10), Far Field, mean + S.D., Distance = 55 km, Chandra Intensity Attenuation = 1.5 units. I_s = (8.5)			
Soft Site	330	48	23
Hard Site	340	30	24
Magnitude = 7.5*, Attenuated 55 km			
Soft Site	330	52	60
Hard Site	320	23	18
* Bollinger (1983) pg T1: M_b = 6.7, equivalent to M = 7.5.			

Table 5 Stephen . Pt Powerhouse Earthquake Time History Selection - Hard Sites

Earthquake Station Comp	EPI dist,km	Mag	Int	Amax, cm/s^2 (Scale Factor)	Vmax, cm	A/V	Site	Selection Basis	File Shake Eqk #
Target	50	7.5		330	48	11	hard	#Mag	
	50		Is8.5	320	23	14	hard	#Int	
Recorded Strong Motion Time Histories									
San Fernando 234 Figuero	41	6.5ML	Io11	195.6 (1.67)	16.8	11.6	H,b-1 S4	Dbase	USACA02.055 Cal58 DB#1
Imperial Val Superstition Mtn	58	6.6ML	Io09	189.2 (1.69)	9.0	21.0	H,f+1 S1	Mag	USACA24.058 Cal139
Loma Prieta Golden Gate	100	7.1ML	Io08	238.8 (1.37)	35.5	6.7	H,brdg S1	Dbase	USACA57.072 Cal349
Coalinga Fault Zone 14	41	6.5		268.4 (1.20)	28.8	9.3	H	Mag	USACA52.124 Cal189 DB#3
""	""	""		257.0 (1.26)	35.4	7.3	H	Mag	USACA52.125 Cal190
Campania-Luciana Sturno NS	35	6.5ML	Io09 Is08	220.8* (1.47)	42.2*	5.2	H	Int	ITA03.006 ITA20
"" "" WE	""	""	""	327.6* (0.99)	70.2*	4.7	""	""	ITA03.006 ITA21

NOTES: { +Dbase query for (epi:20-70) & (H) & (a/v:10-14)} {*uncorrected} {# KCN Charts}

Table 5 Stephen Pt Powerhouse Earthquake Time History Selection - Hard Sites

Earthquake Station Comp	EPI dist,km	Mag	Int	Amax, cm/s² (Scale Factor)	Vmax, cm	A/V	Site	Selection Basis	File Shake Eqk #
Loma Prieta Gilroy#7 0Deg	24	7.1Ms	Io08 Is07	205.6 (1.56)	16.6	12.4	H	+Dbase	GILROY#7.v2 Cal381 DB#2
"" 90Deg	""	""	""	314.3 (1.03)	16.3	19.3	""	""	GILROY#7.v2 Cal381
Loma Prieta SFO TransAm bld	61	7.1	Io8 Is6	104 (3.12)	8.8	11.8	H,bldg	+Dbase	USACA57.060 Cal344
Morgan Hill Coyote Lake Dam	25	6.2ML	Io07	639.8 (0.51)	51.9	12.3	H,abut S2	+Dbase	USACA36.005 Cal229
Whittier Narrows Cedar Hill Nur. 90	43	5.9ML	Io08	526.9 (0.62)	24.2	21.8	H S4	Int	USACA39.013 Cal270
"" 0	""	""	""	397.5 (0.82)	19.2	20.7	""	""	USACA39.013 Cal271

NOTES: { +Dbase query for (epi:20-70) & (H) & (a/v:10-14)} {*uncorrected} {# KCN Charts}

Table 6 St Stephen Powerhouse, SC | Latitude: +33.4 Longitude: - 79.9 Probabilistic Hazard Spectra - Source USGS NEHRP November 1996 Maps					
Return Period (yr)	Annual Frequency of Exceedence	Peak Ground Acceleration (g's)	Peak Spectral Acceleration (g's)		
			0.2 sec	0.3 sec	1.0 sec
475	0.0021	0.16	0.305	0.230	0.070
975	0.0010	0.36	0.680	0.530	0.190
2475	0.0004	0.84	1.590	1.240	0.460
Extrapolated					
144	0.0069	0.041-0.050	0.013-0.019	0.056-0.068	0.081-0.095

Table 7a. Deaggregated Seismic Hazard Charleston, SC % Contribution to Hazard to PGA for Return Period 2475 yrs						
Distance (km)	Moment Magnitude					
	5	5.5	6	6.5	7	7.5
25	4.646	0	5.669	5.162	3.491	56.908
50	0	0.123	0.462	1.088	1.616	15.414
75	0	0.002	0.015	0.086	0.266	3.681
100	0	0	0.001	0.011	0.055	0.816
125	0	0	0	0.003	0.019	0.364
150	0	0	0	0.001	0.006	0.082
175	0	0	0	0	0.002	0.007
200	0	0	0	0	0	0.002
225	0	0	0	0	0	0.001

Table 7b. Deaggregated Seismic Hazard Charleston, SC % Contribution to Hazard to SA of 1 Hz for Return Period 2475 yrs						
Distance (km)	Moment Magnitude					
	5	5.5	6	6.5	7	7.5
25	0	0.032	0.691	2.538	2.994	56.841
50	0	0.001	0.064	0.697	1.837	19.594
75	0	0	0.006	0.126	0.579	7.96
100	0	0	0.001	0.033	0.209	2.831
125	0	0	0	0.016	0.114	1.836
150	0	0	0	0.008	0.063	0.608
175	0	0	0	0.004	0.036	0.085
200	0	0	0	0.002	0.023	0.028
225	0	0	0	0.001	0.017	0.022
250	0	0	0	0.001	0.011	0.016
275	0	0	0	0	0.006	0.013
300	0	0	0	0	0	0.013
325	0	0	0	0	0	0.01
350	0	0	0	0	0	0.007
375	0	0	0	0	0	0.006
400	0	0	0	0	0	0.005
425	0	0	0	0	0	0.004
450	0	0	0	0	0	0.004
475	0	0	0	0	0	0.003
500	0	0	0	0	0	0.003

Table 7c. Deaggregated Seismic Hazard Charleston, SC % Contribution to Hazard to SA of 3.3 Hz for Return Period 2475 yrs						
Distance (km)	**Moment Magnitude**					
	5	**5.5**	**6**	**6.5**	**7**	**7.5**
25	0	1.074	2.937	4.099	3.378	57.495
50	0	0.034	0.281	1.042	1.902	17.925
75	0	0.001	0.017	0.136	0.464	5.85
100	0	0	0.002	0.026	0.133	1.727
125	0	0	0.001	0.01	0.062	1.002
150	0	0	0	0.004	0.028	0.29
175	0	0	0	0.001	0.012	0.032
200	0	0	0	0.001	0.006	0.008
225	0	0	0	0	0.003	0.005
250	0	0	0	0	0	0.005
275	0	0	0	0	0	0.003
300	0	0	0	0	0	0.001
325	0	0	0	0	0	0.001

Table 7d. Deaggregated Seismic Hazard Charleston, SC % Contribution to Hazard to SA of 5 Hz for Return Period 2475 yrs						
Distance (km)	Moment Magnitude					
	5	5.5	6	6.5	7	7.5
25	2.18	0	3.931	4.413	3.347	57.418
50	0	0.076	0.388	1.097	1.784	17.042
75	0	0.002	0.023	0.13	0.395	5.165
100	0	0	0.002	0.022	0.104	1.417
125	0	0	0.001	0.007	0.045	0.749
150	0	0	0	0.002	0.018	0.199
175	0	0	0	0.001	0.007	0.02
200	0	0	0	0	0.003	0.005
225	0	0	0	0	0	0.004
250	0	0	0	0	0	0.002
275	0	0	0	0	0	0.001

Table 8 - Static Soil properties

Material type		Layer to layer elevation Interface (feet)	total unit weight	Drained soil properties	Soil strengths used for slope stability calculations
					Undrained soil properties
Select and pervious fill			120 pcf	$\phi_d = 35°$	$\phi_u = 35$
Impervious fill			120 pcf	$\phi_d = 28°$	$\phi_u = 13°$ $c_u = 600$ psf
Zone II fill			120 pcf	$\phi_d = 32°$	$\phi_u = 23°$ $c_u = 400$ psf
Zone I fill		70 ft	125 pcf	$\phi_d = 31°$	$\phi_u = 13°$ $c_u = 600$ psf
Upper natural soil zone		41 ft	120 pcf	$\phi_d = 28°$	$\phi_u = 24°$ $c_u = 700$ psf
Middle natural soil zone	Non horizontal layers		110 pcf	$\phi_d = 26°$	$\phi_u = 13°$ $c_u = 500$ psf
	Short horizontal layers	18 ft	110 pcf	$\phi_d = 18°$	$\phi_u = 13°$ $c_u = 500$ psf
Lower natural soil zone		-28 ft	115 pcf	$\phi_d = 28°$	$\phi_u = 15°$ $c_u = 800$ psf
Shale		-41 ft	105 pcf	$\phi_d = 28°$ $c_d = 1000$	$\phi_u = 20°$ $c_u = 2600$ psf
Limestone			135 pcf	$\phi_d = 28°$ $c_d = 5700$	$\phi_u = 37°$ $c_u = 5700$ psf

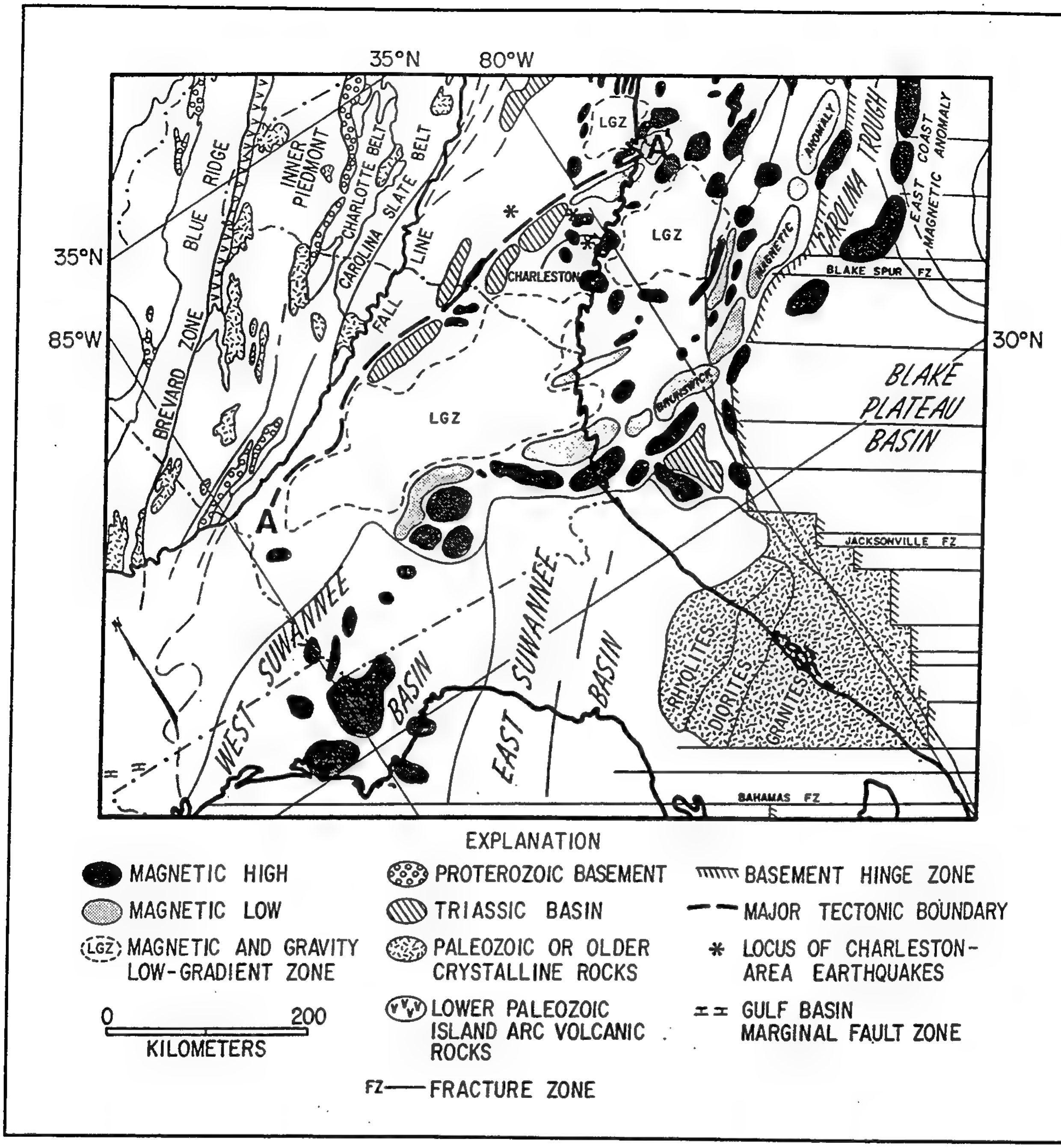


Figure 1. Geology and tectonism in the Charleston, South Carolina, region. From Klitgard et al. (1983).

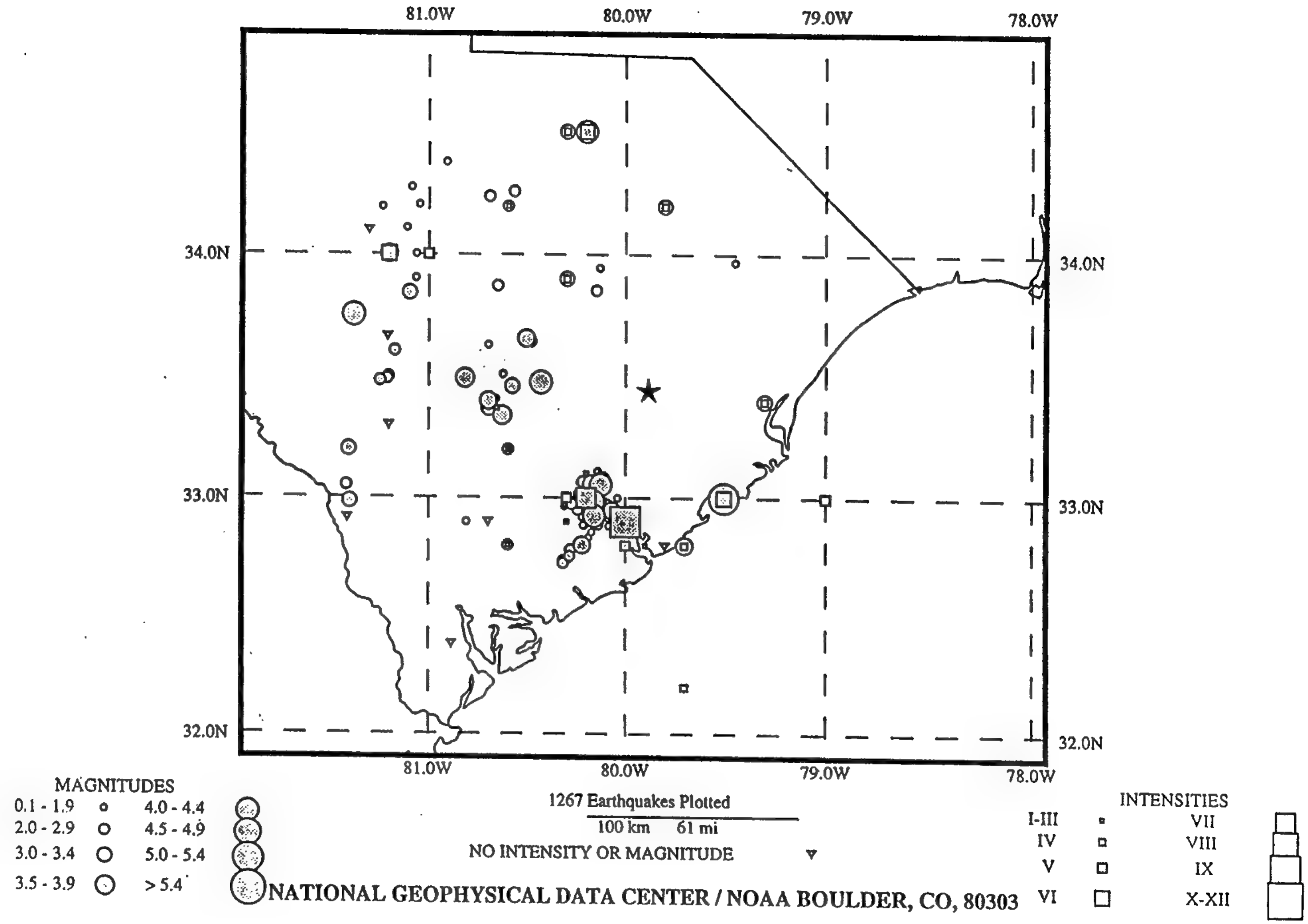


Figure 2. Historic seismicity within 150 km of the St. Stephen Powerhouse (shown with a star). The data are listed in Appendix A.

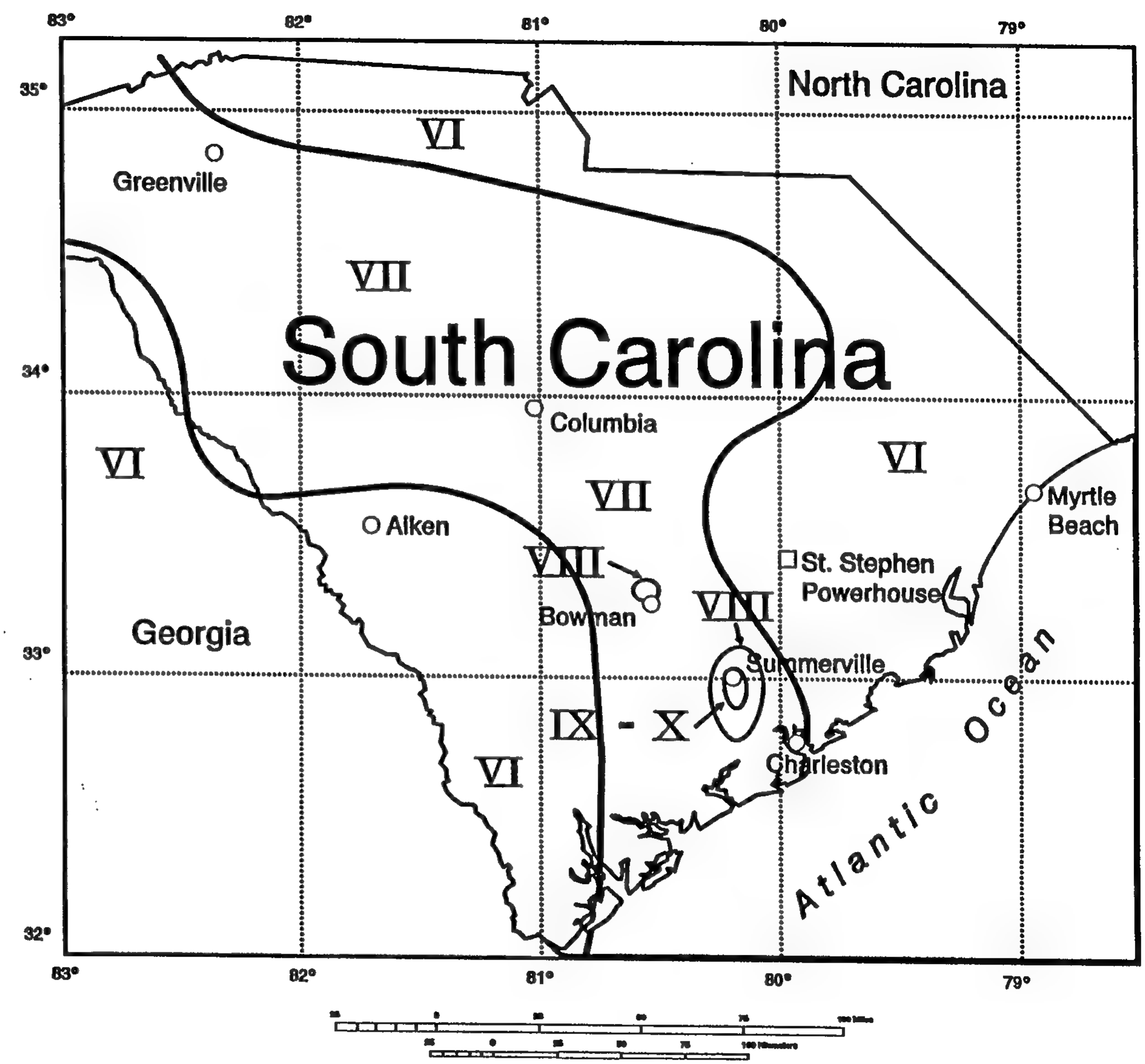


Figure 3. Seismic source zones in South Carolina.

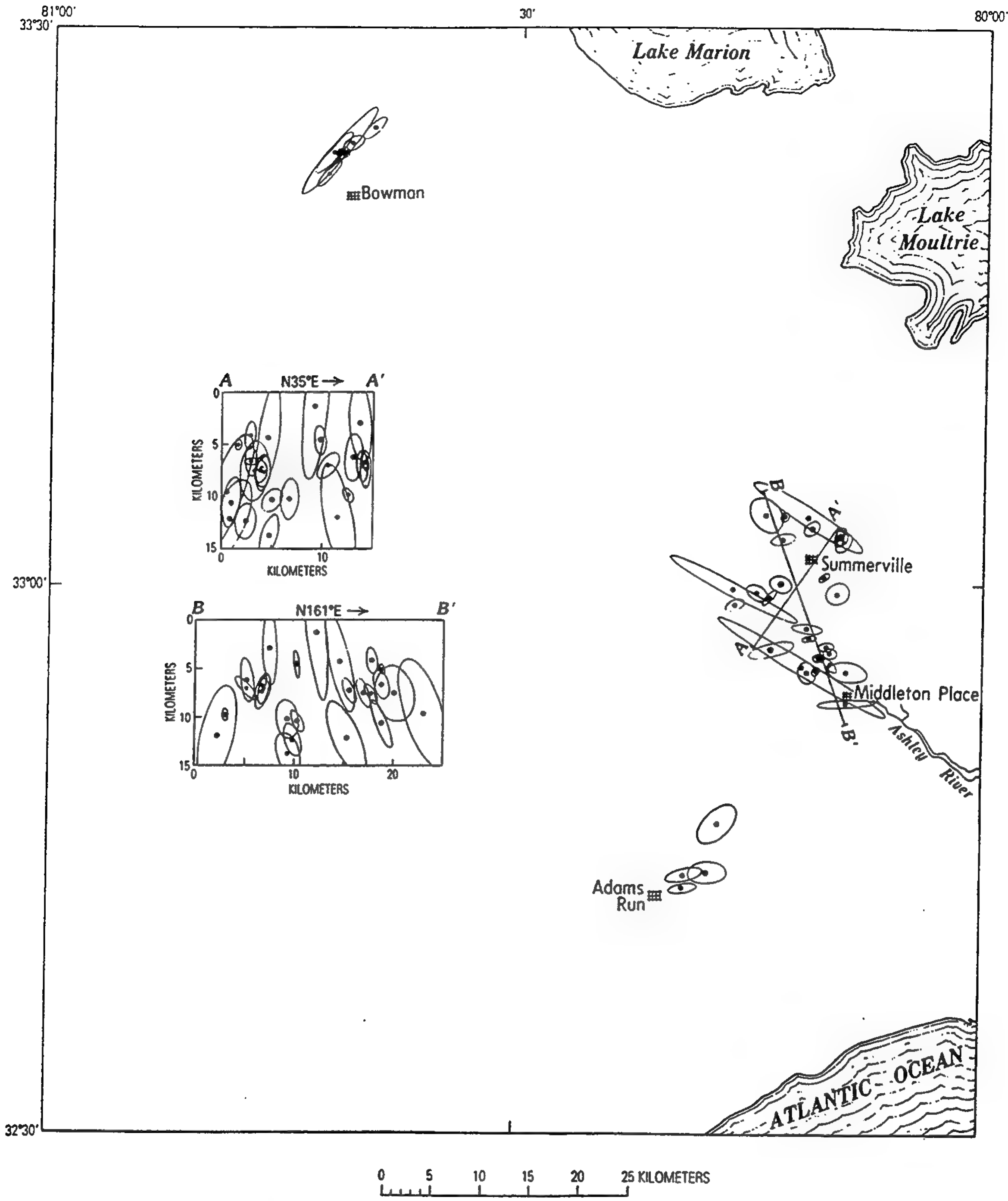


Figure 4. Locations of earthquakes and their hypocenters near Charleston, South Carolina. The data are from recordings made between March 1973 and December 1979. From Tarr and Rhea (1983).

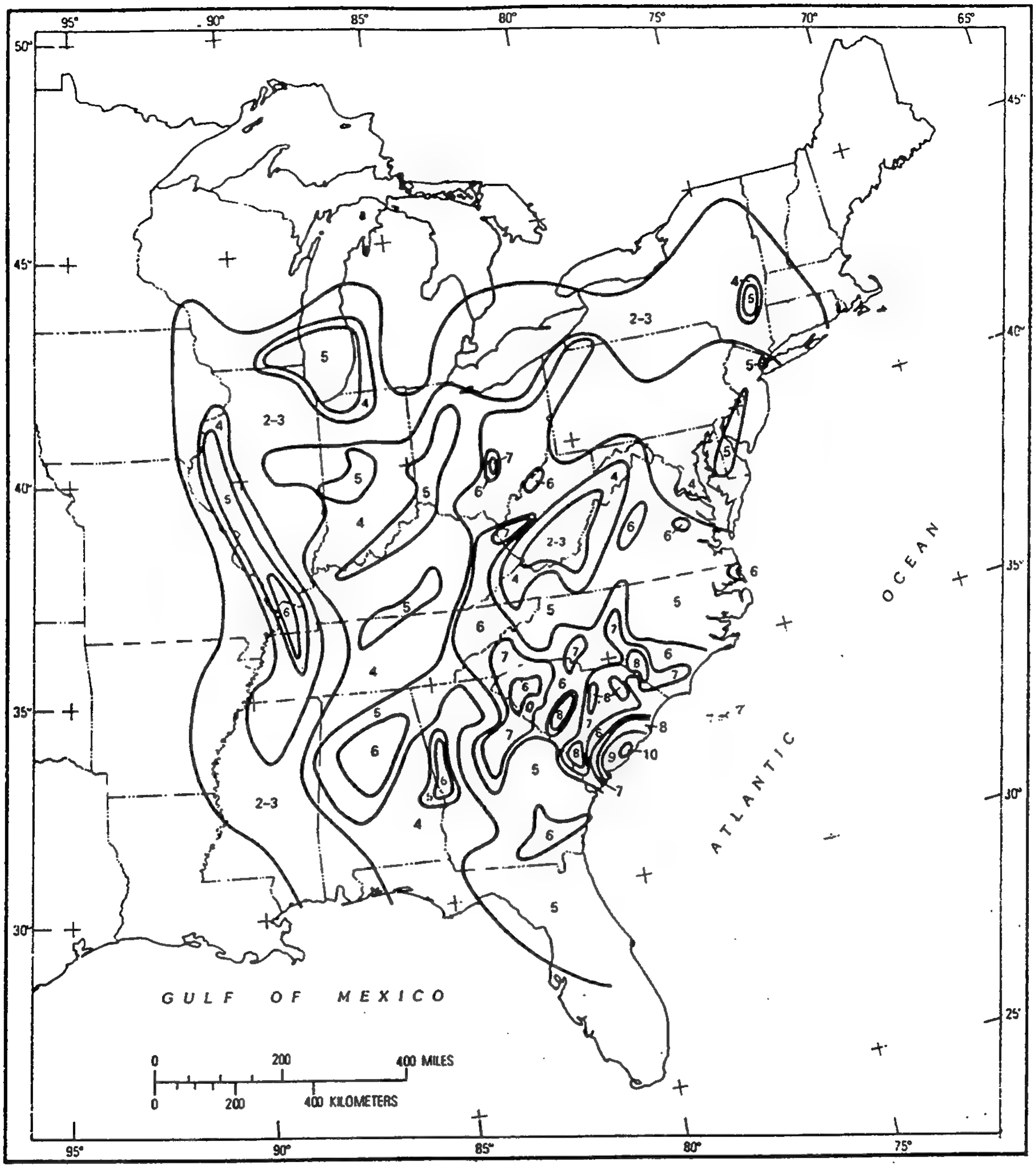


Figure 5. Distribution of Modified Mercalli intensities for the Charleston, South Carolina, earthquake of September 1, 1886. From Bollinger (1977).

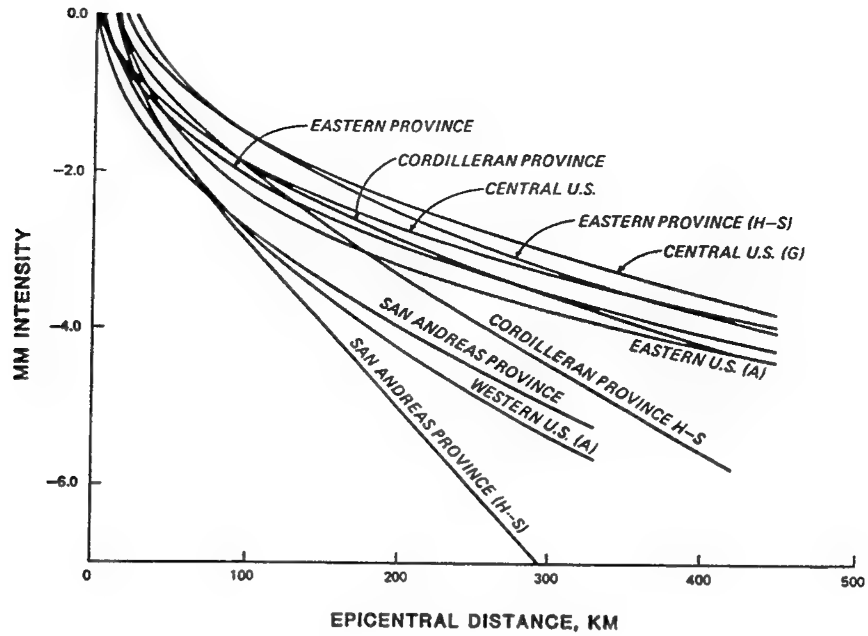


Figure 6. Attenuation of MM intensities with distance in various areas of the United States. From Chandra (1979).

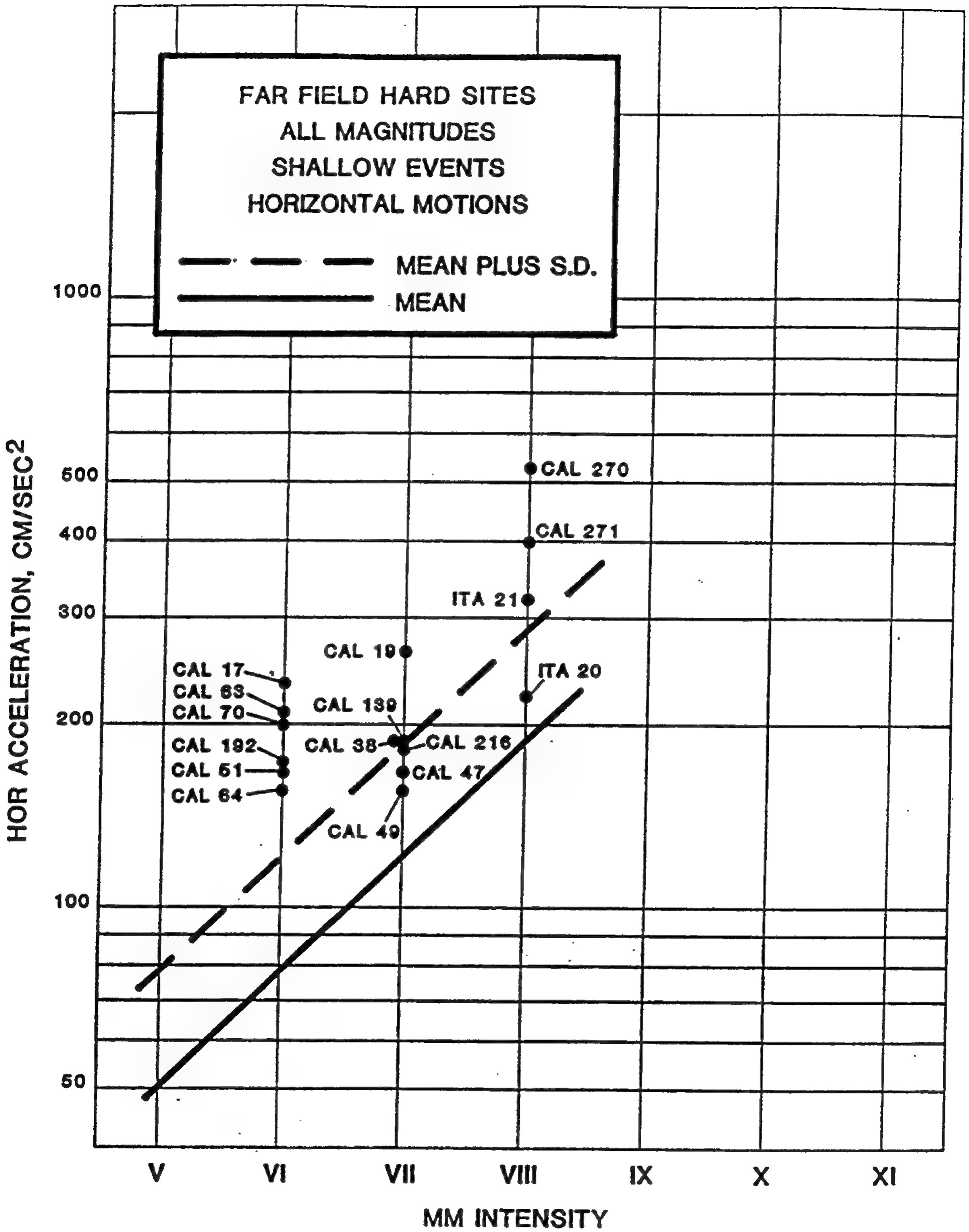


Figure 7. Accelerograms for acceleration and intensity for shallow earthquakes at far-field hard sites.

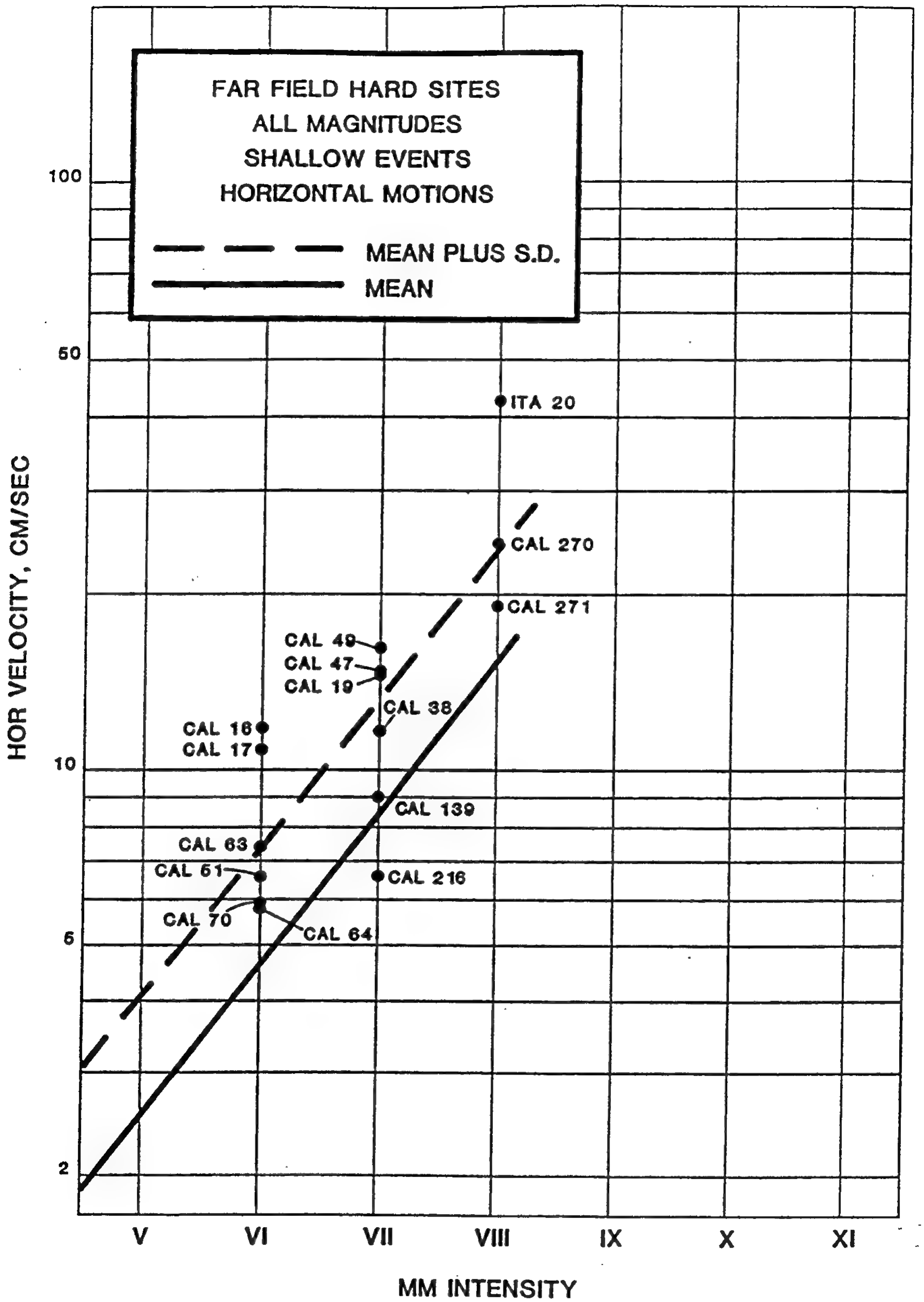


Figure 8. Accelerograms for velocity and intensity for shallow earthquakes at far-field hard sites.

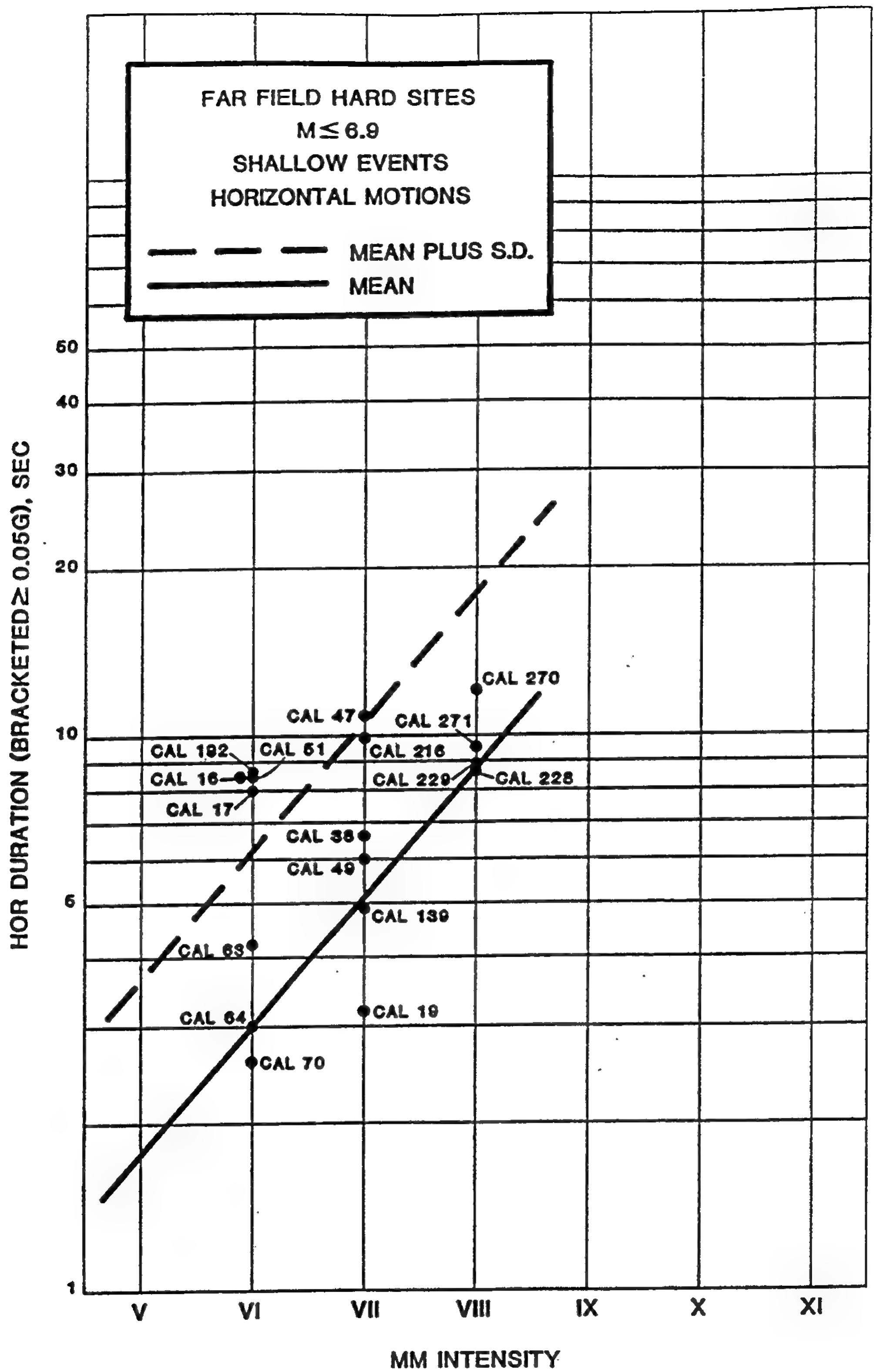


Figure 9. Accelerograms for duration and intensity for shallow earthquakes at far-field hard sites.

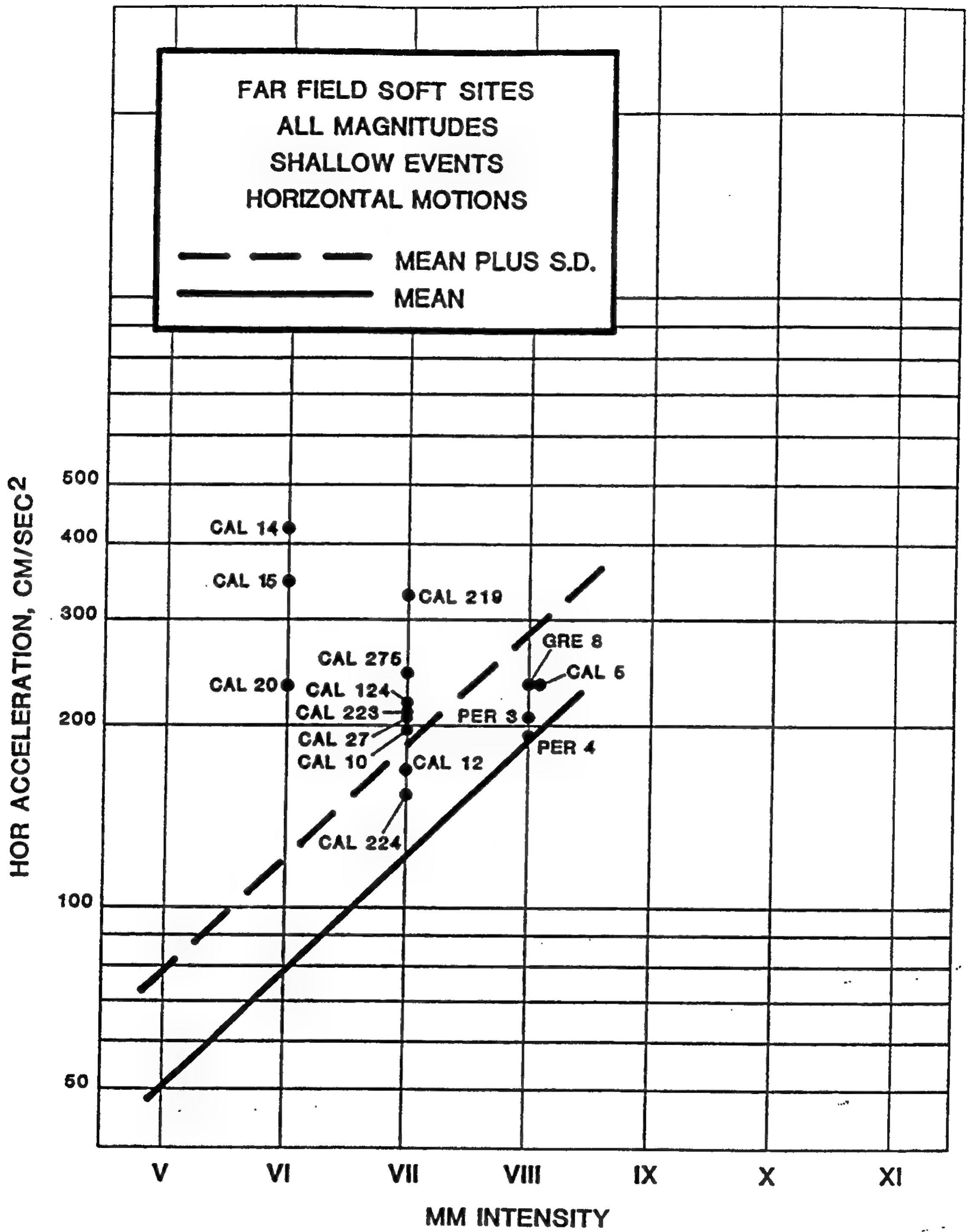


Figure 10. Accelerograms for acceleration and MM intensity for shallow earthquakes at far-field soft sites.

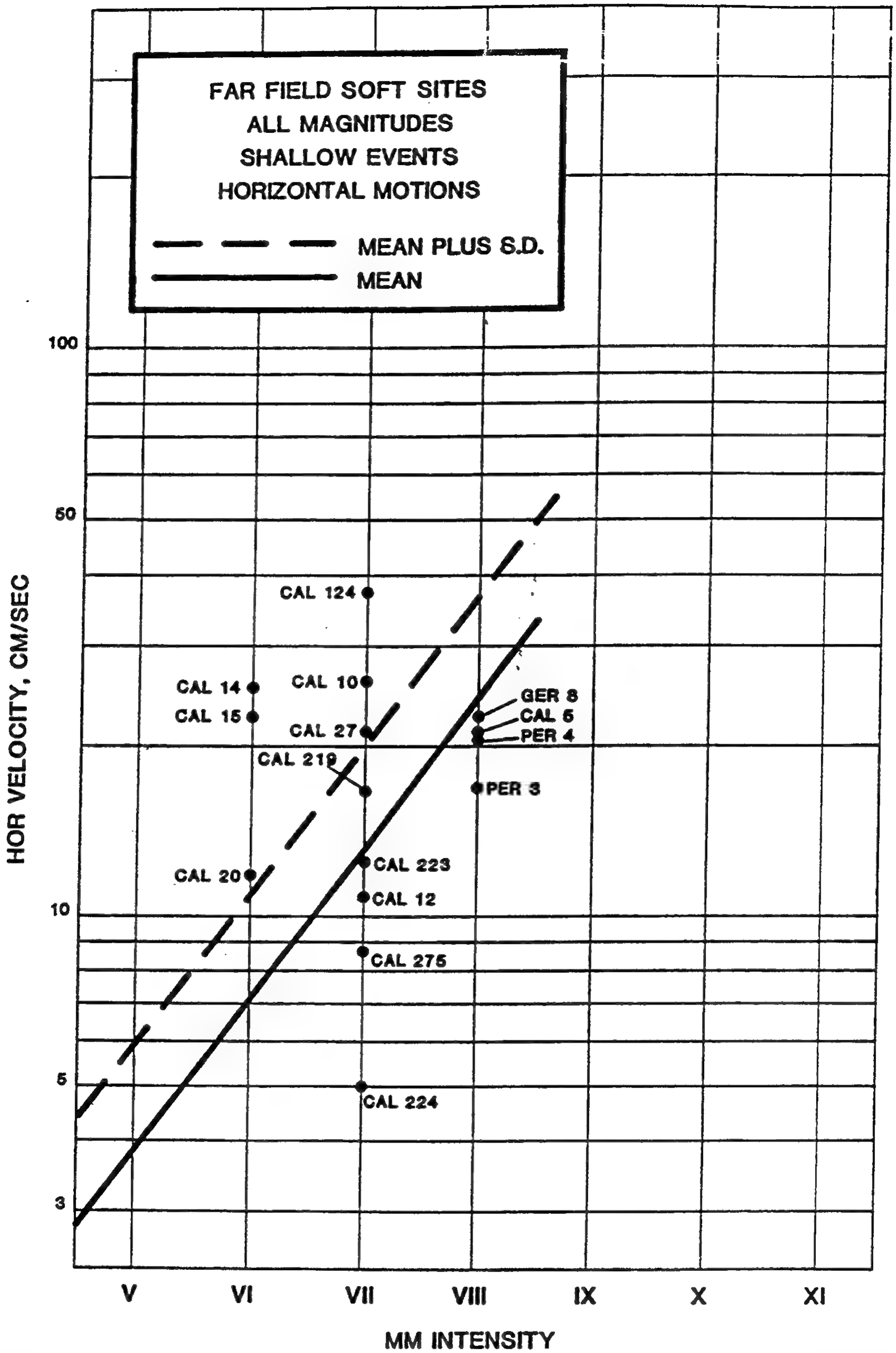


Figure 11. Accelerograms for velocity and intensity for shallow earthquakes at far-field soft sites.

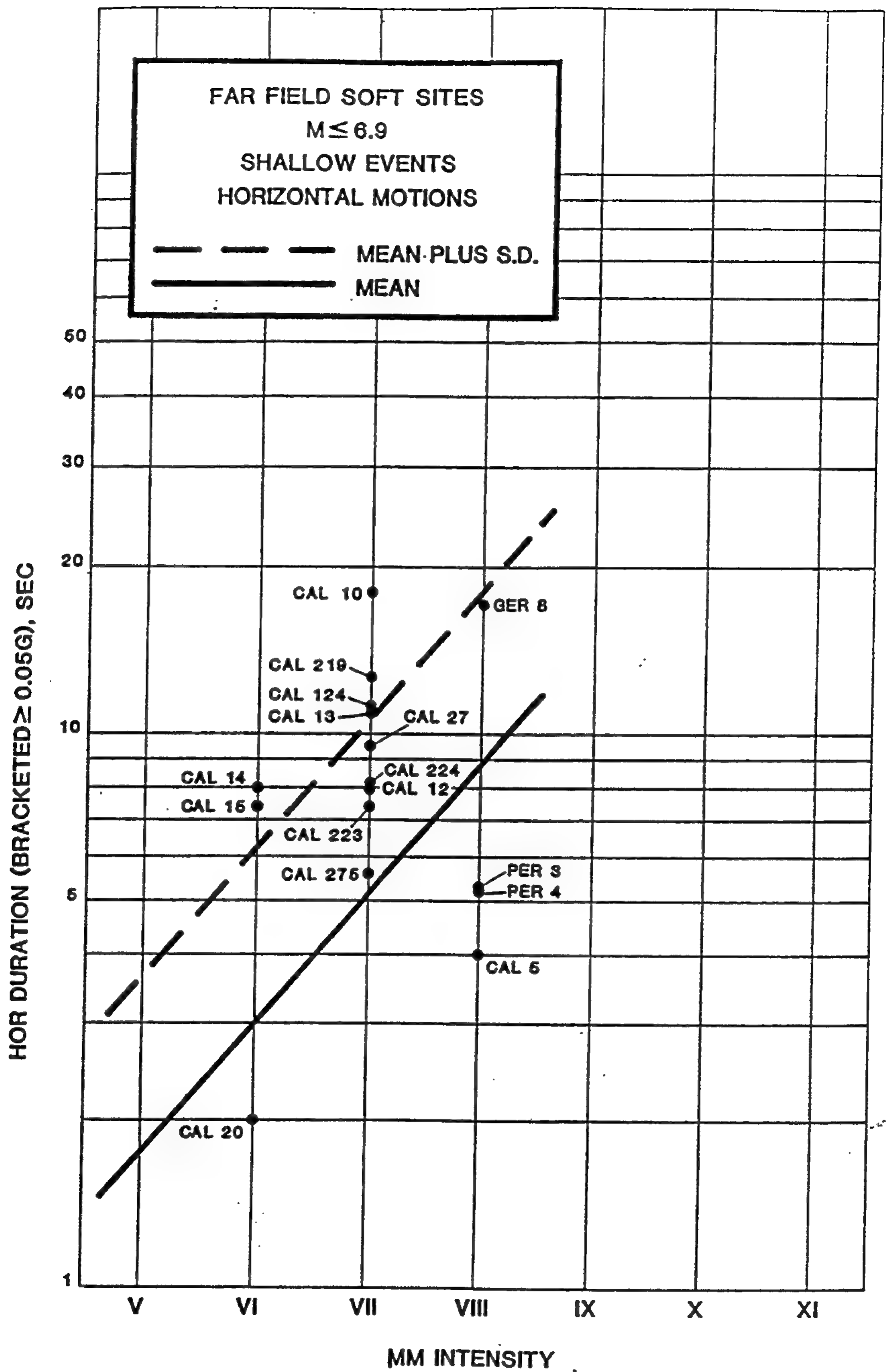


Figure 12. Accelerograms for duration and intensity for shallow earthquakes, M ≥ 6.9 at far-field soft sites.

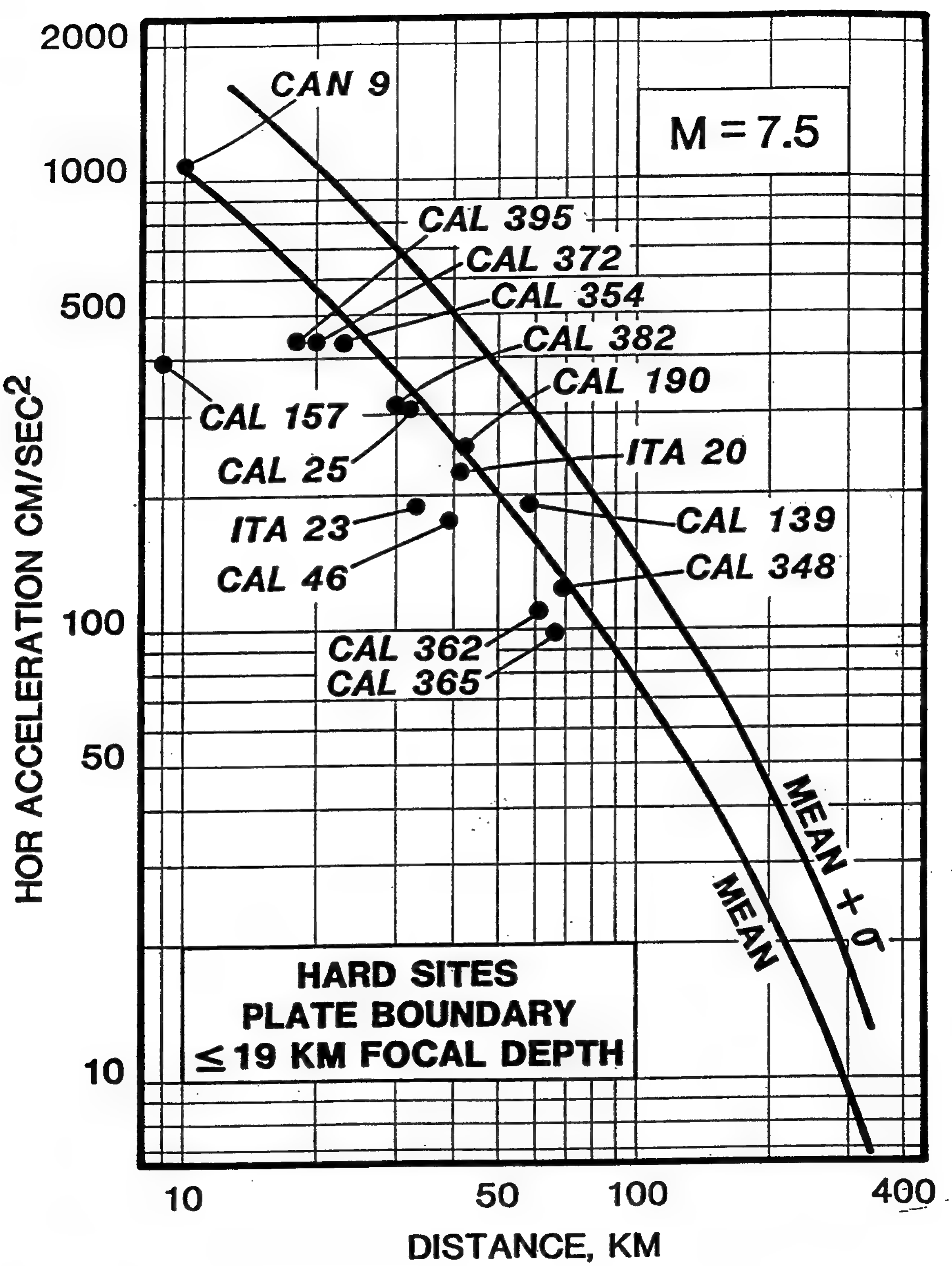


Figure 13. Accelerograms for acceleration, M = 7.5, and distance from source for shallow earthquakes at hard sites.

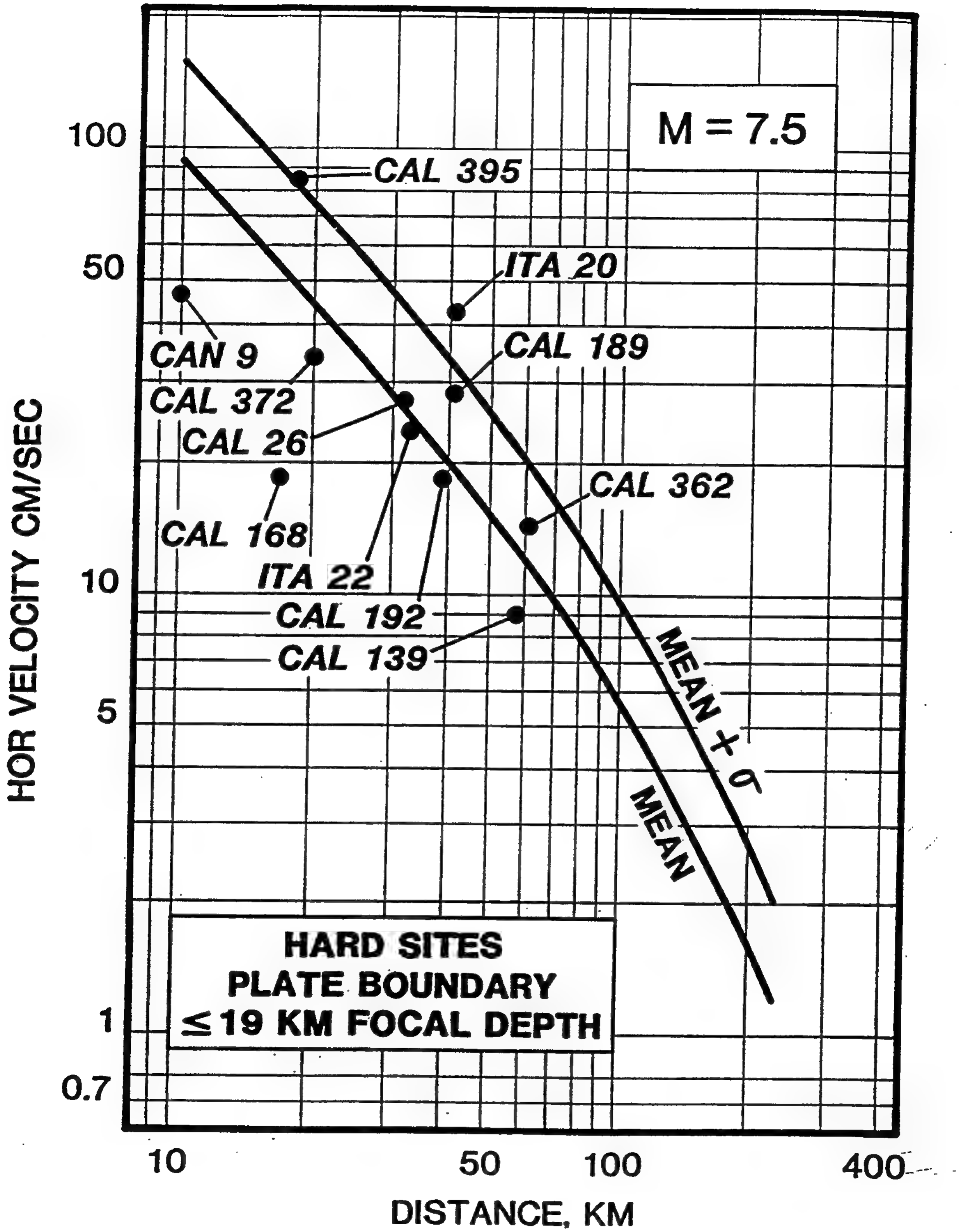


Figure 14. Accelerograms for velocity, M = 7.5, and distance from source for shallow earthquakes at hard sites.

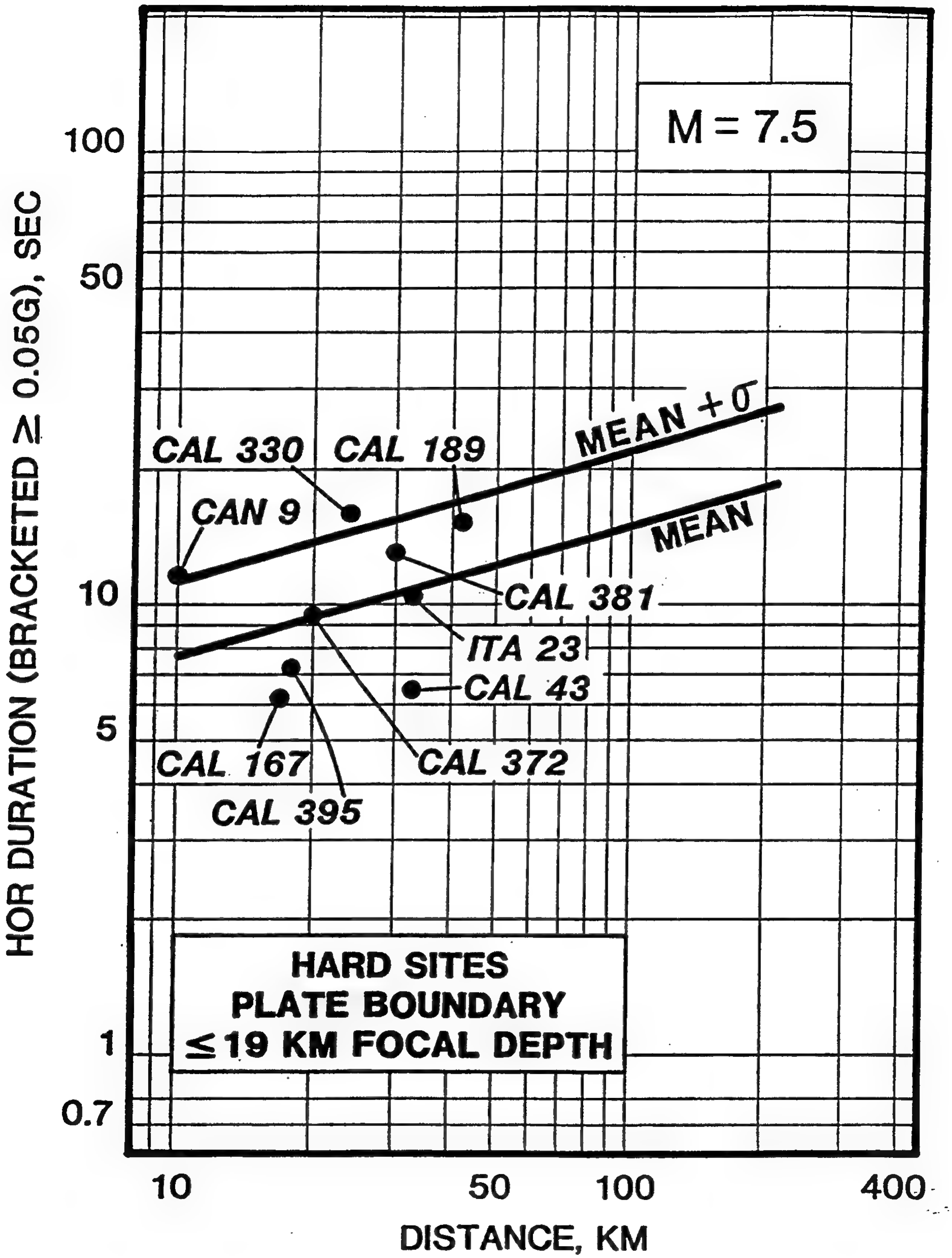


Figure 15. Accelerograms for duration, M = 7.5, and distance from source for shallow earthquakes at hard sites.

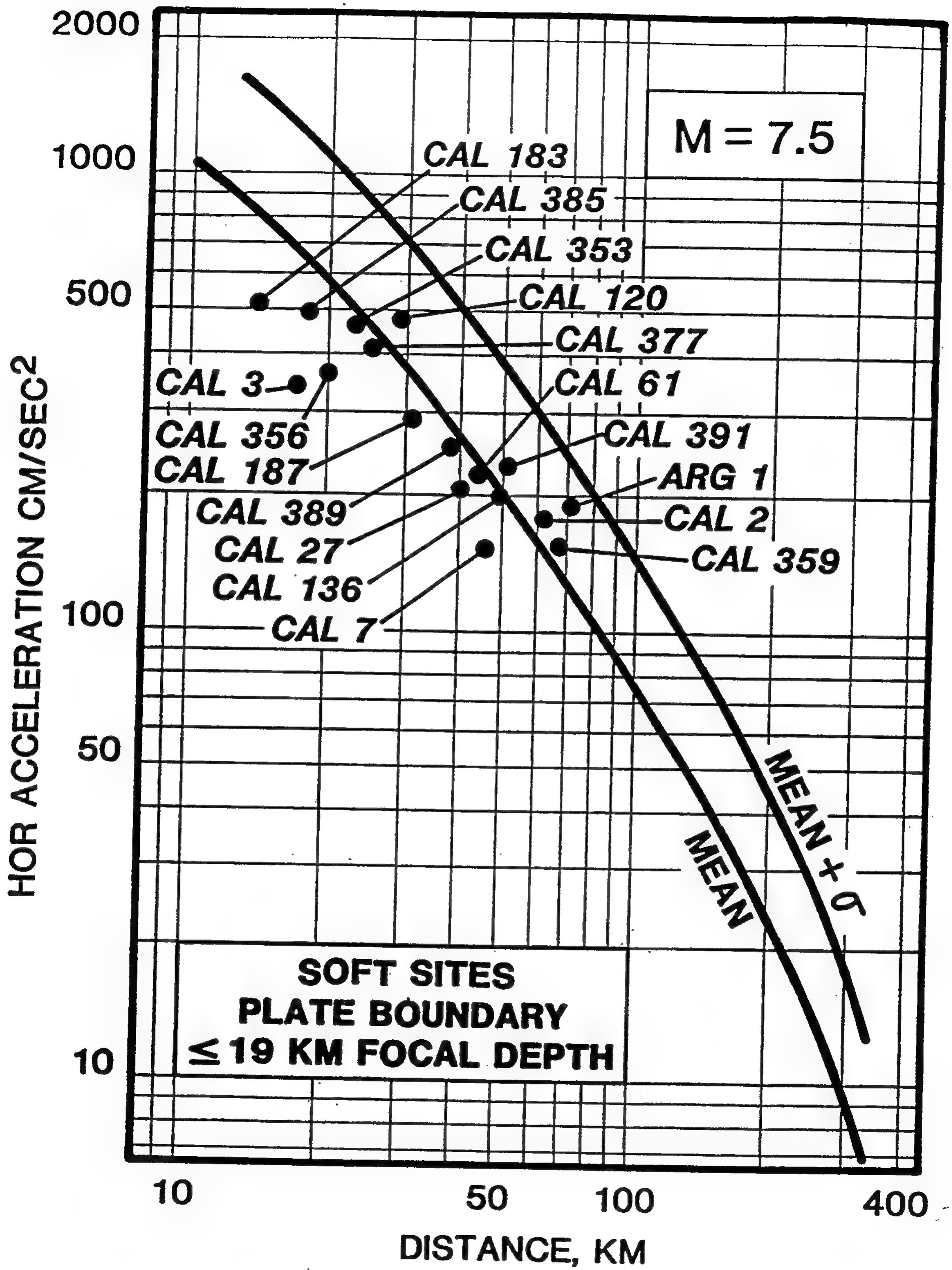


Figure 16. Accelerograms for acceleration, M = 7.5, and distance from source for shallow earthquakes at soft sites.

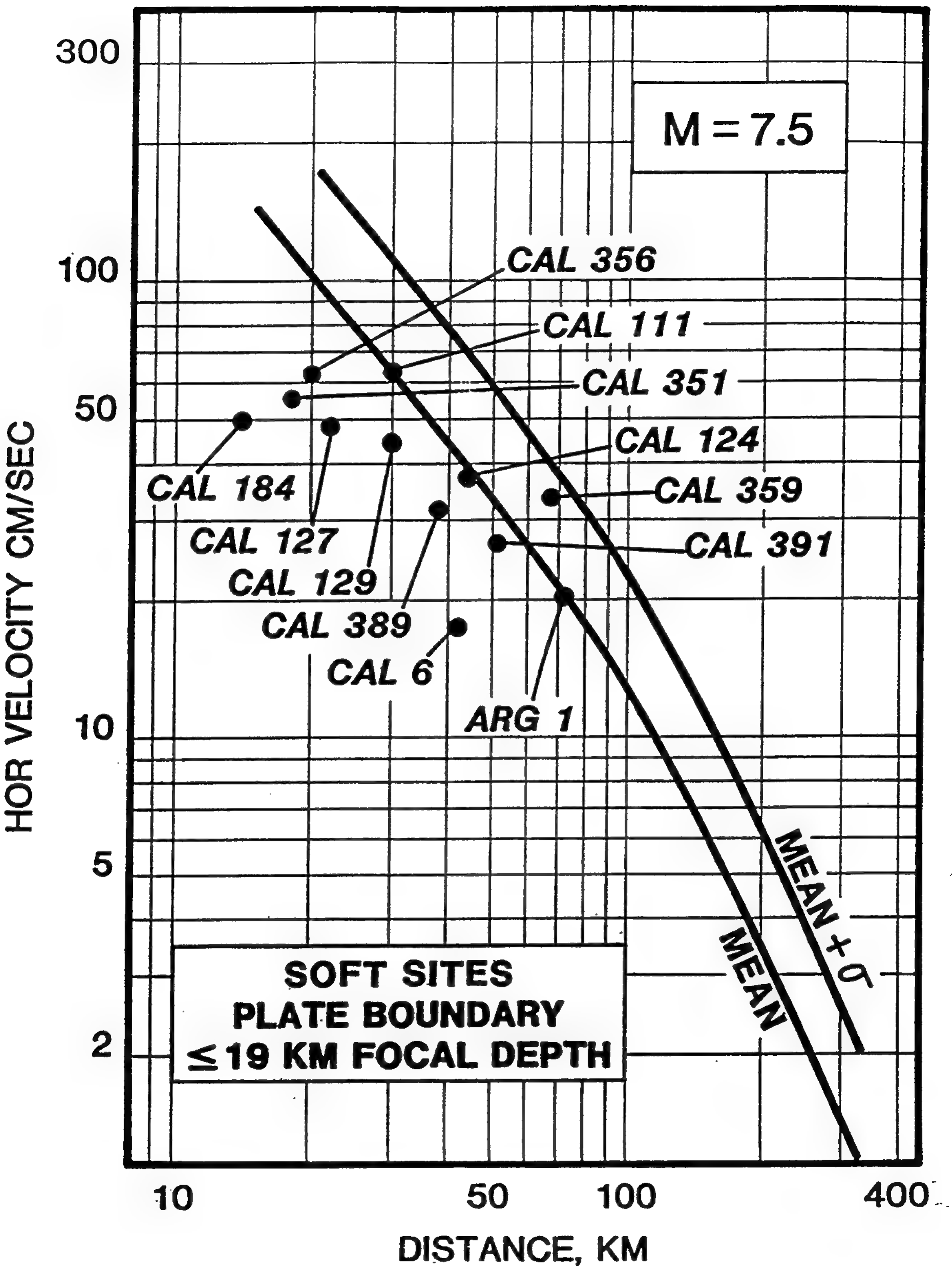


Figure 17. Accelerograms for velocity, M = 7.5, and distance from source for shallow earthquakes at soft sites.

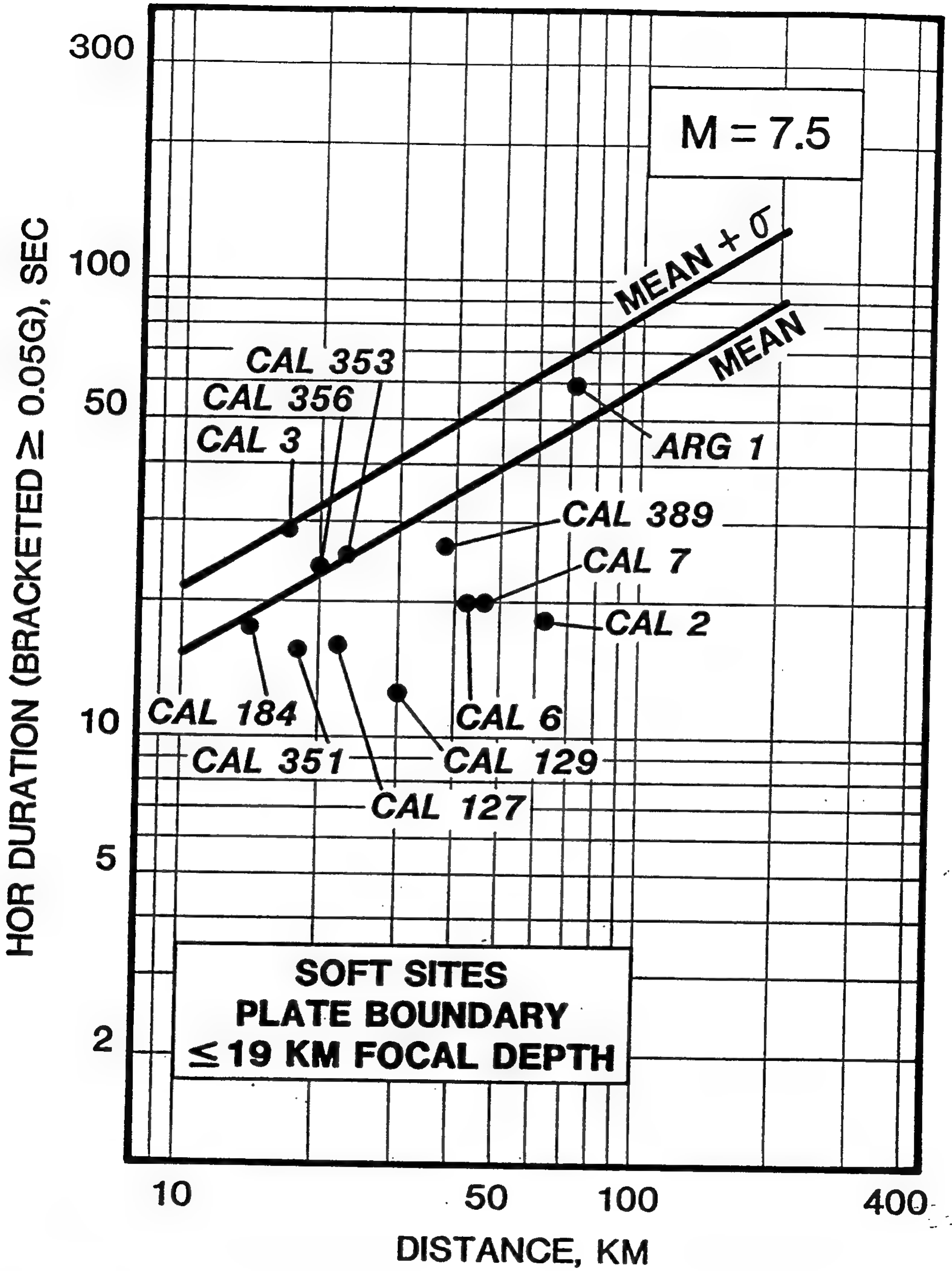
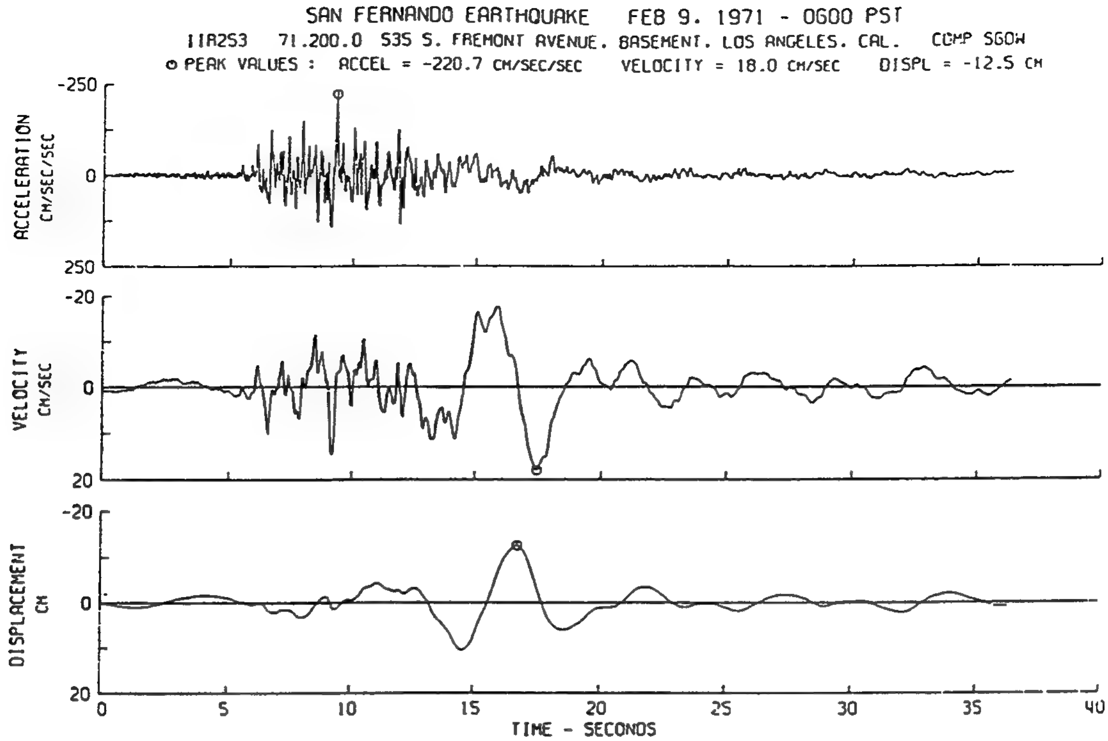
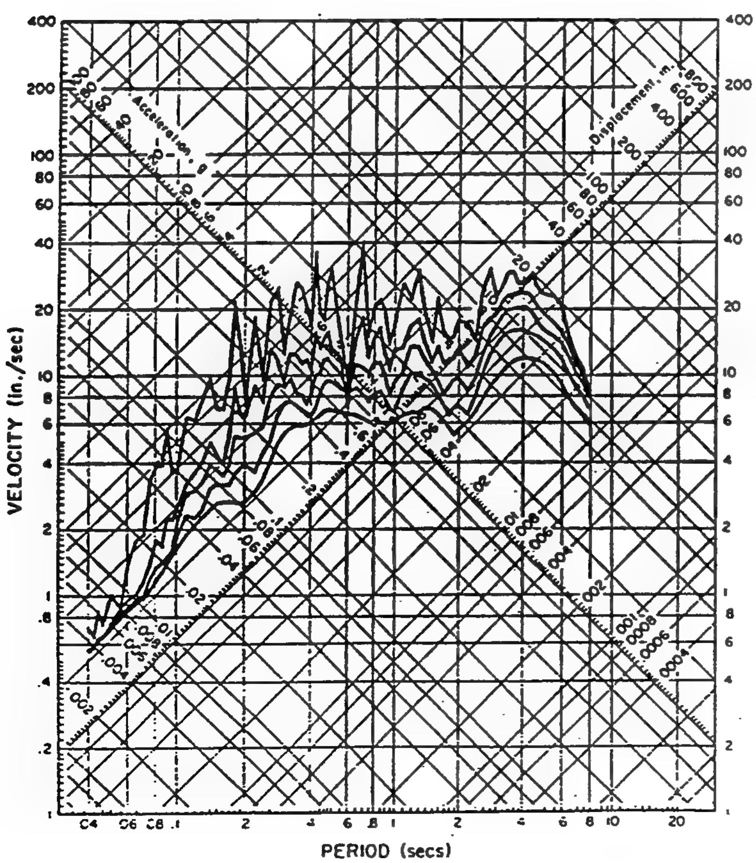


Figure 18. Accelerograms for duration, M = 7.5, and distance from source for shallow earthquakes at soft sites.



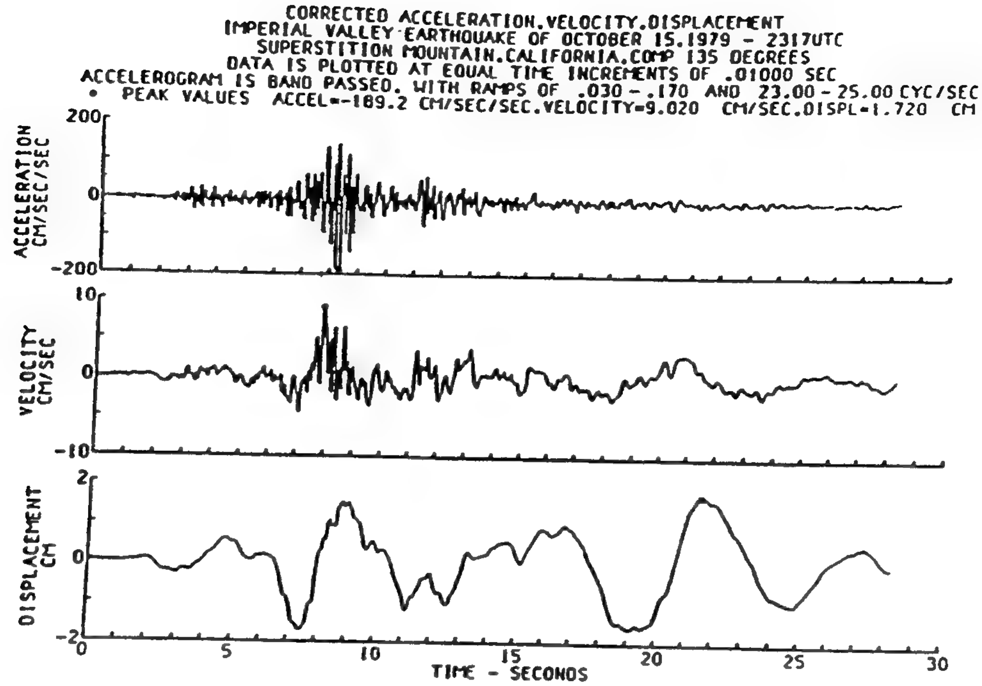
CIT EERL 74-56

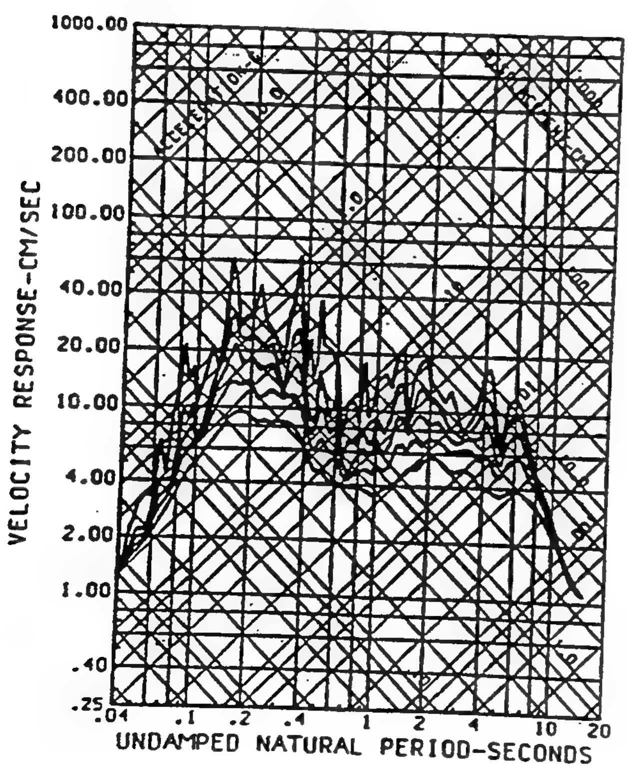


CIT EERL 74-85

535 S. FREMONT AVENUE. BASEMENT
LOS ANGELES. CAL.
IIIR253 71.200.0 COMP S60W
DAMPING VALUES ARE
0. 2. 5. 10 AND 20 PERCENT OF CRITICAL

Figure 19. San Fernando earthquake Feb 9, 1971 - 0600 PST, CAL 61.

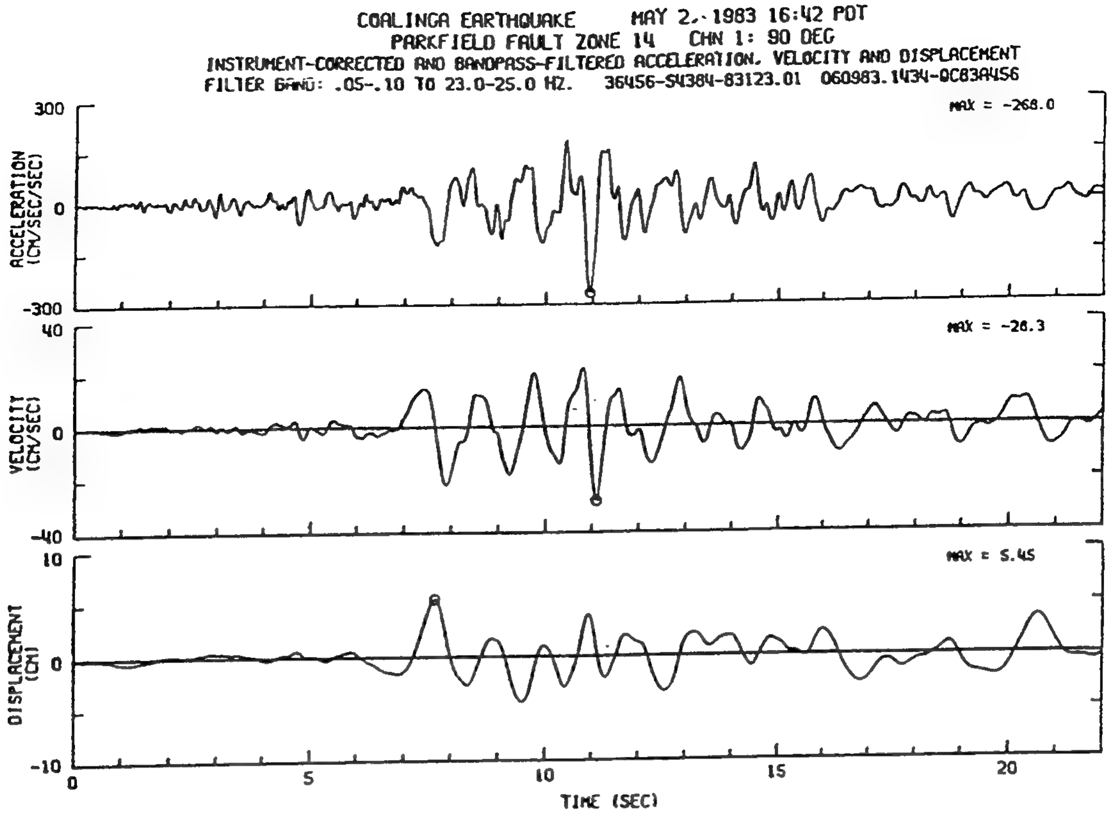




USGS OF 80-703

SEISMIC ENGINEERING BRANCH/USGS
BAND PASSED FROM
.030- .170 TO 23.00-25.00 HZ
2317.135DEG
CRITICAL DAMPING
0.2.5.10.20 PERCENT

Figure 20. Superstition MT. CAL. 10/15/79, CAL 139.



CDMG PRINTOUT

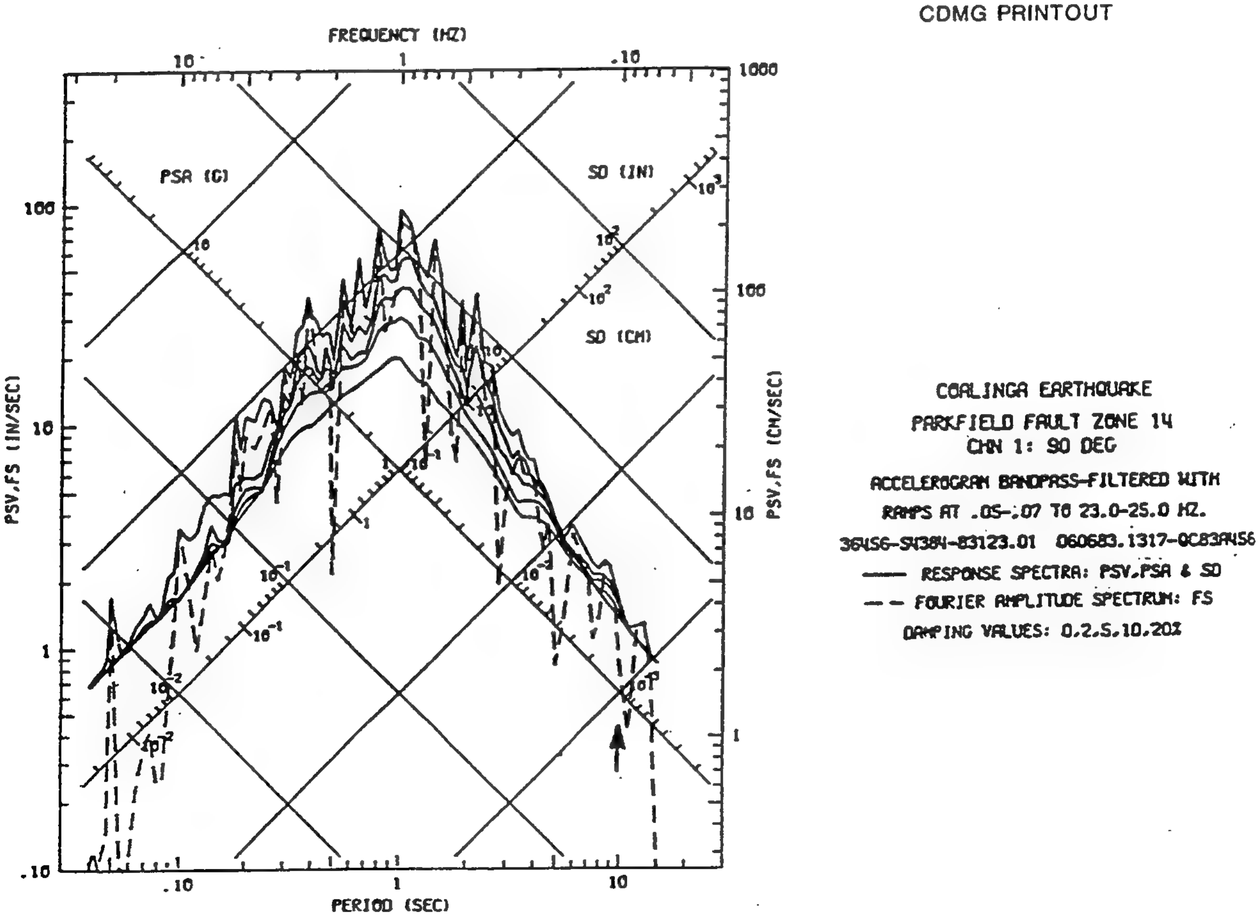
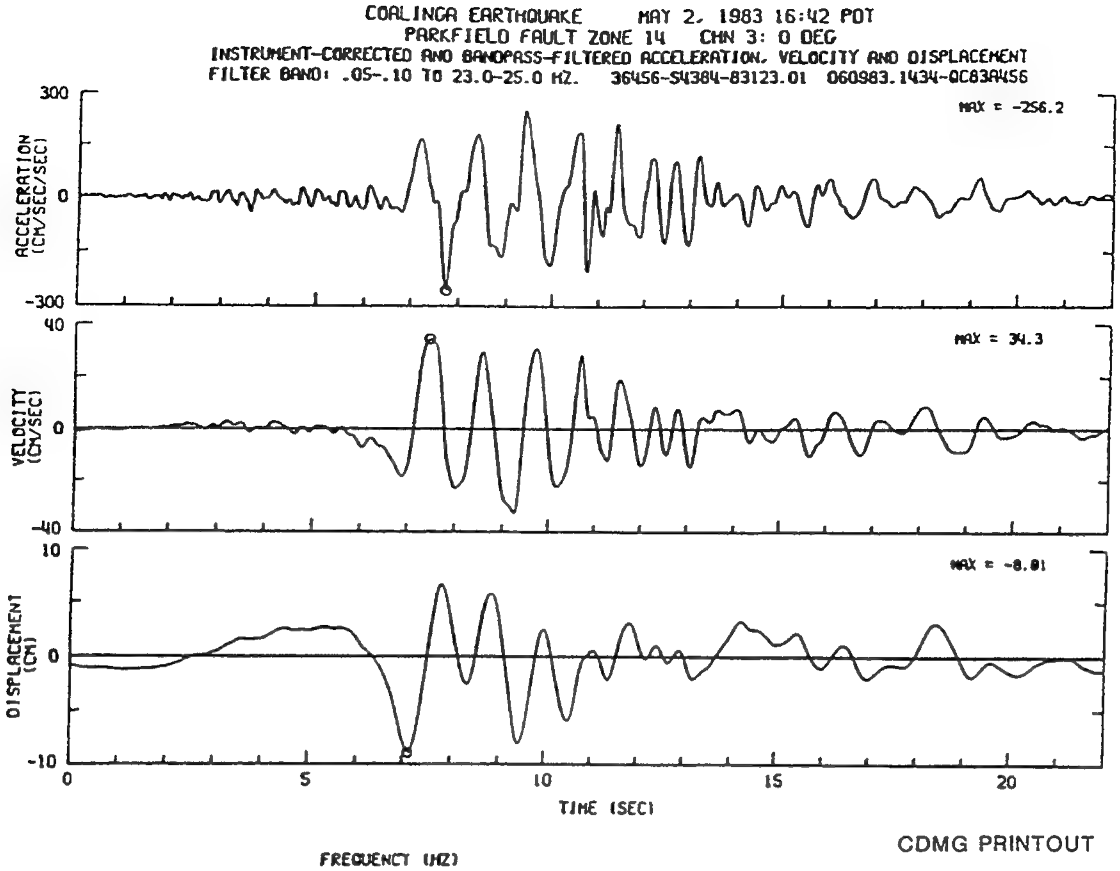


Figure 21. Coalinga Earthquake, Parkfield fault Zone 14, CHN 1: 90 Deg May 2, 1983 16:42 PDT, CAL 189.



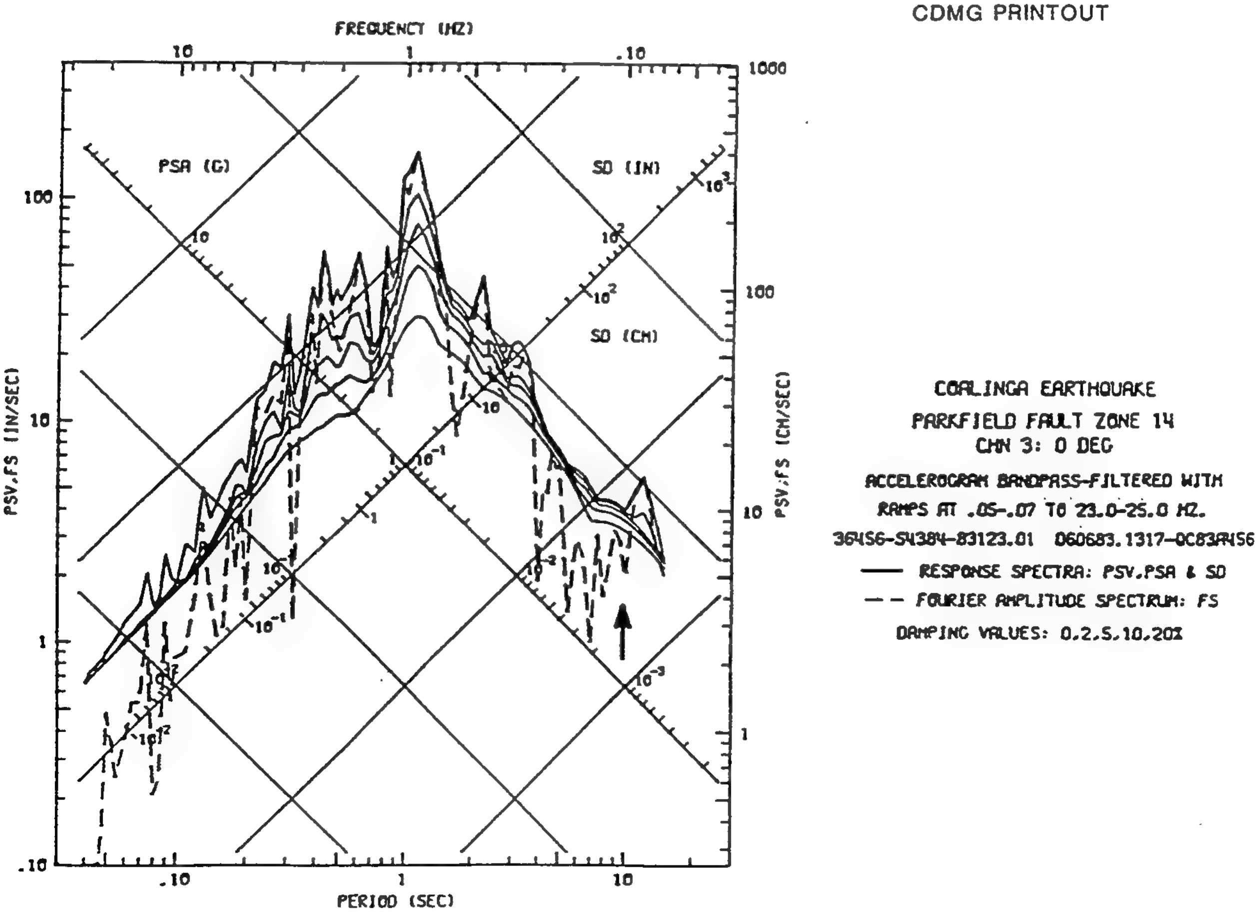
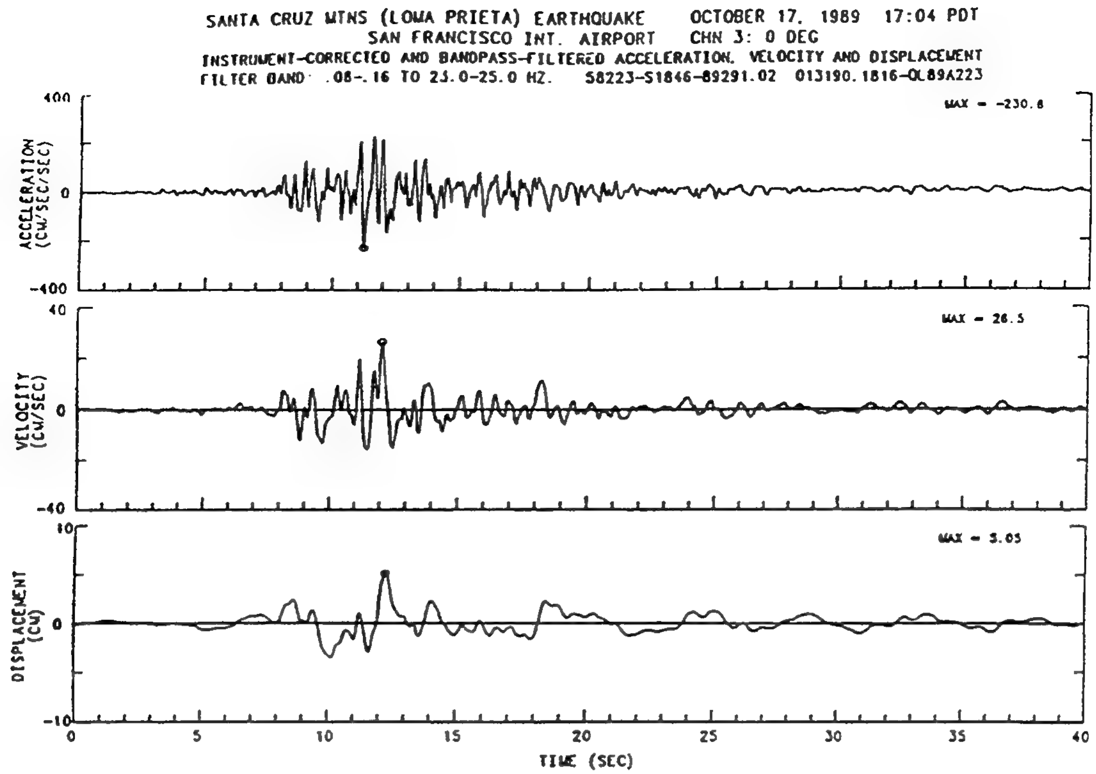
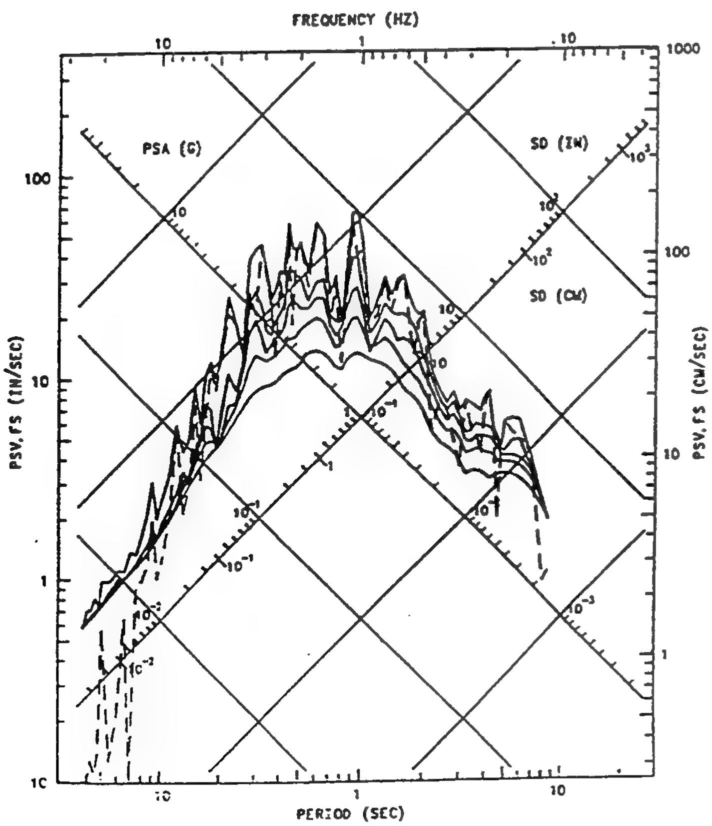


Figure 22. Coalinga Earthquake, Parkfield fault Zone 14, CHN 3: 0 Deg May 2, 1983, 16:42 PDT, CAL 190.

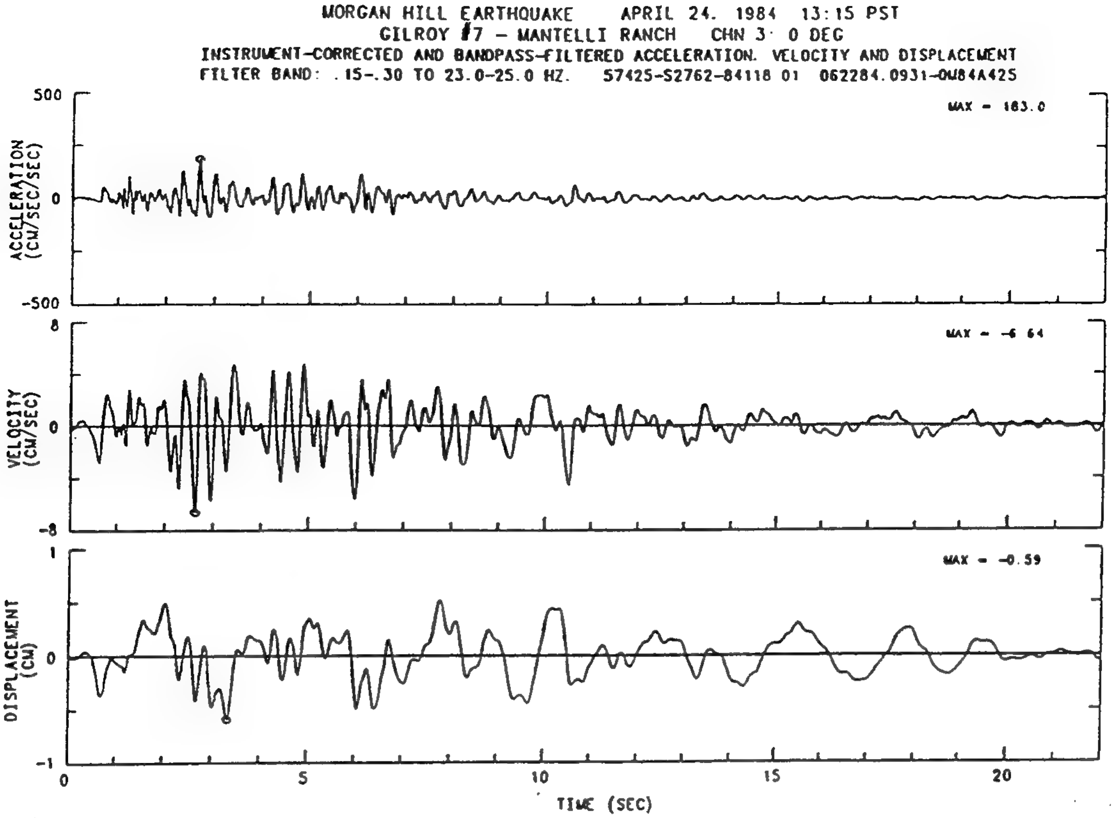




CDMG OSMS 90-01

SAN FRANCISCO INT. AIRPORT
CHN 3: 0 DEG
ACCELEROGRAM BANDPASS-FILTERED WITH
RAMPS AT .08-.16 TO 23.0-25.0 HZ.
58223-S1846-89291.02
013190.1830-QL89A223
—— RESPONSE SPECTRA: PSV, PSA & SD
– – FOURIER AMPLITUDE SPECTRUM: FS
DAMPING VALUES: 0, 2, 5, 10, 20%

Figure 23. Santa Cruz Mtns (Loma Prieta) Earthquake, Oct 17, 1989, 17: 04 PDT, CAL 391.



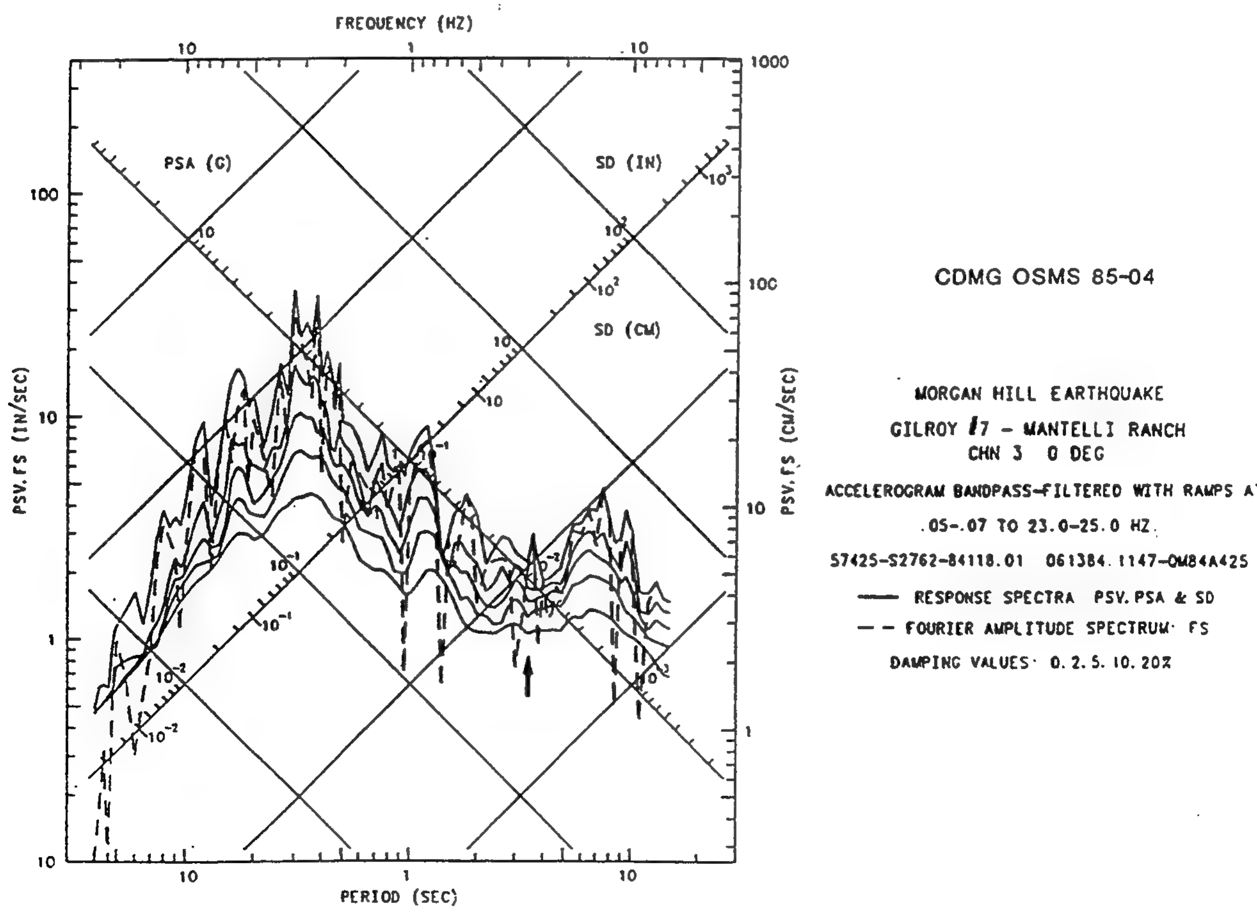
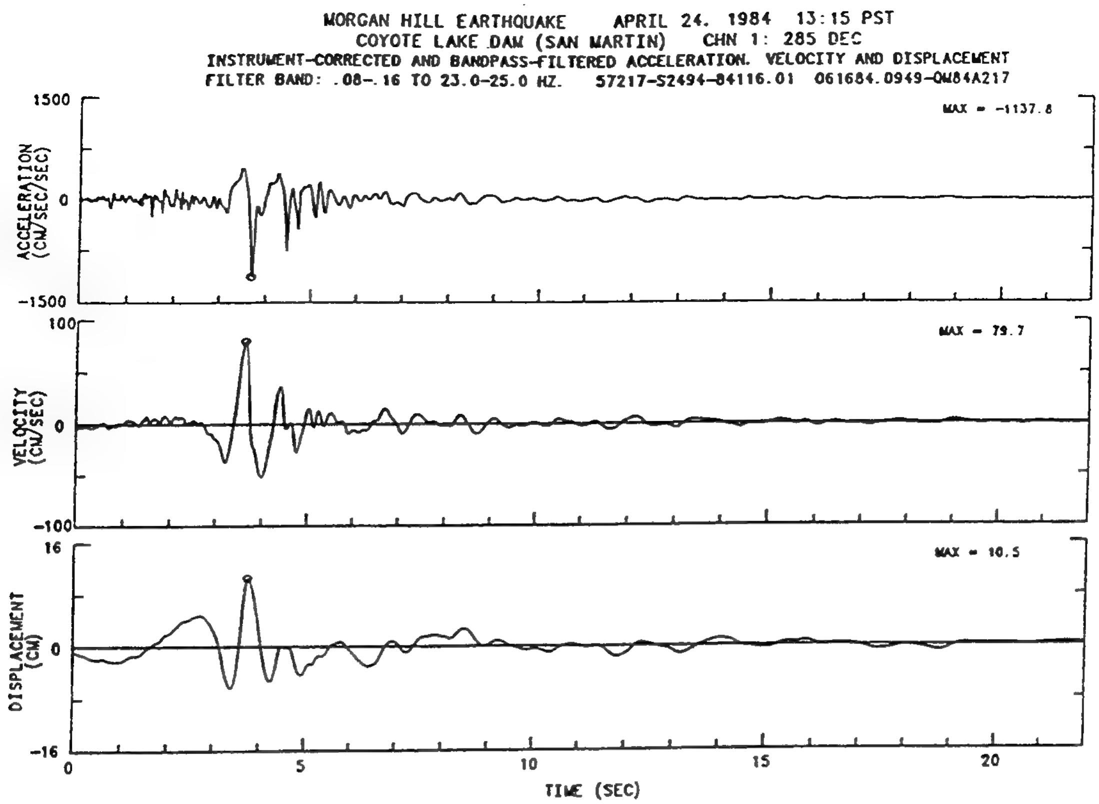
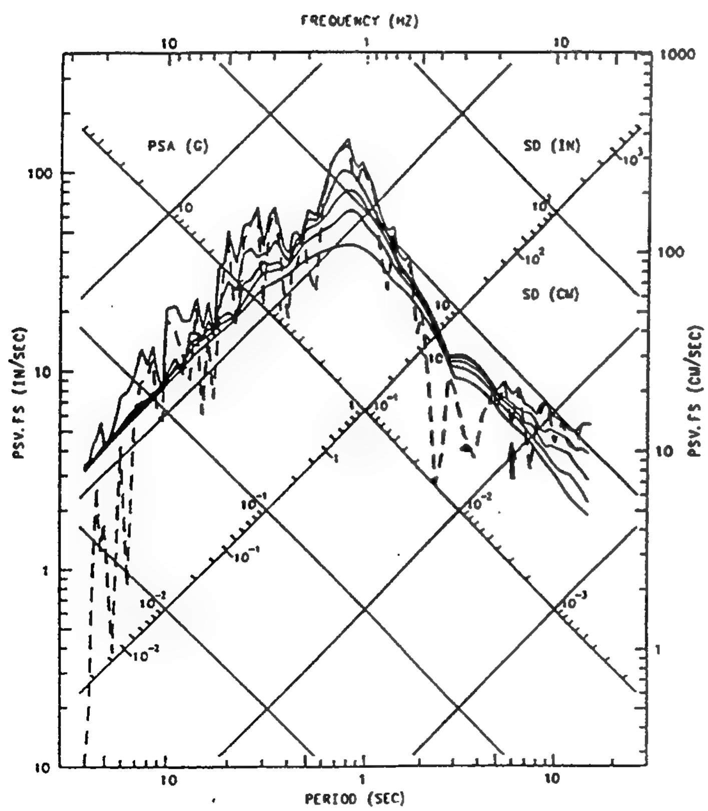


Figure 24. Morgan Hill Earthquake, Gilroy No. 7 - Mantelli Ranch, CHN 3, 0 Deg, April 24, 1984, 13:15 PST, CAL 216.

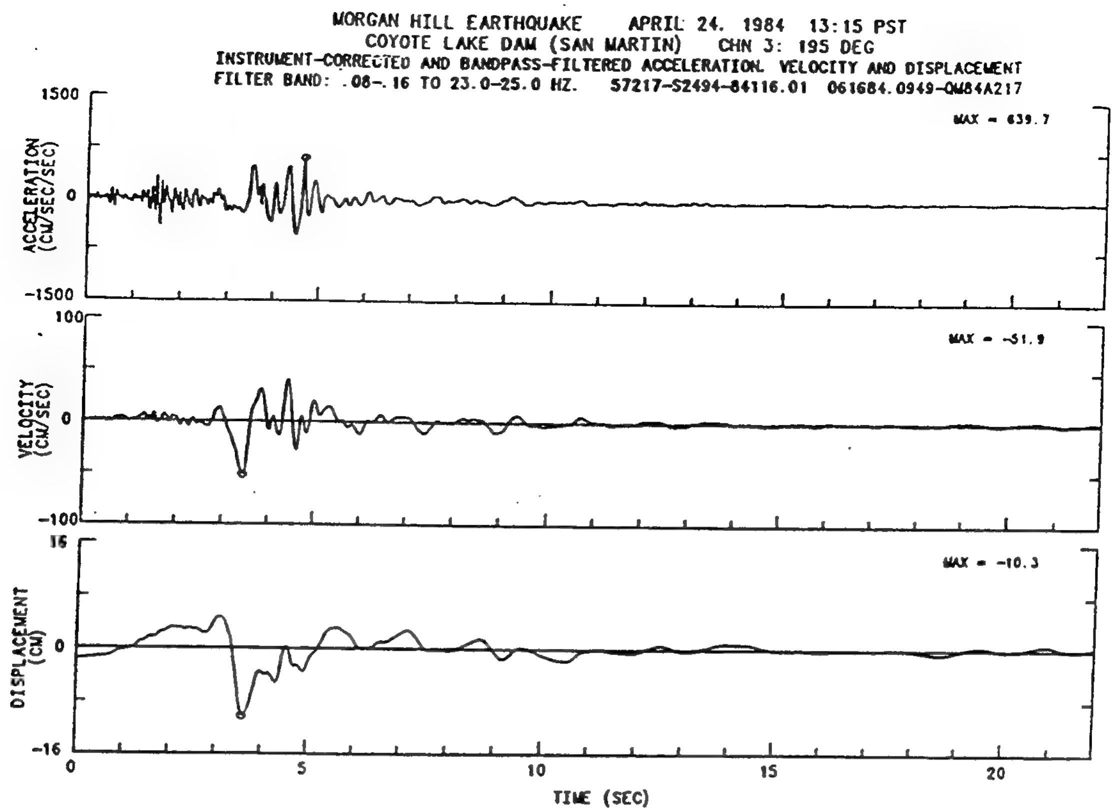




CDMG OSMS 85-04

COYOTE LAKE DAM (SAN MARTIN)
CHN 1: 285 DEG
ACCELEROGRAM BANDPASS-FILTERED WITH
RAMPS AT .05-.07 TO 23 0-25.0 HZ.
57217-S2494-84116.01
061484.1641-QM84A217
—— RESPONSE SPECTRA· PSV.PSA & SD
– – FOURIER AMPLITUDE SPECTRUM· FS
DAMPING VALUES· 0.2.5.10.20%

Figure 25. Morgan Hill Earthquake, April 24, 1984, 13:15 PST, CAL 228.



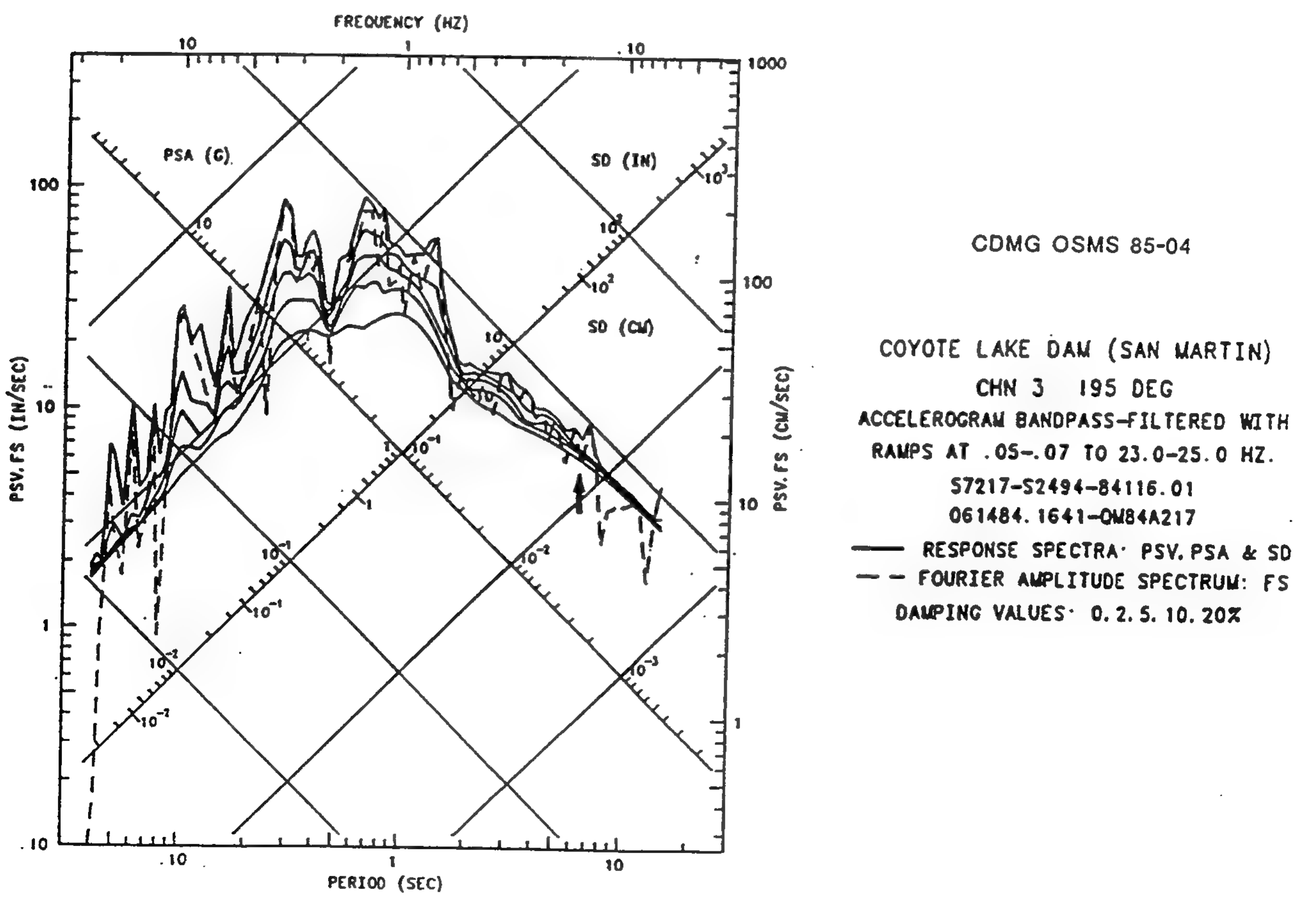
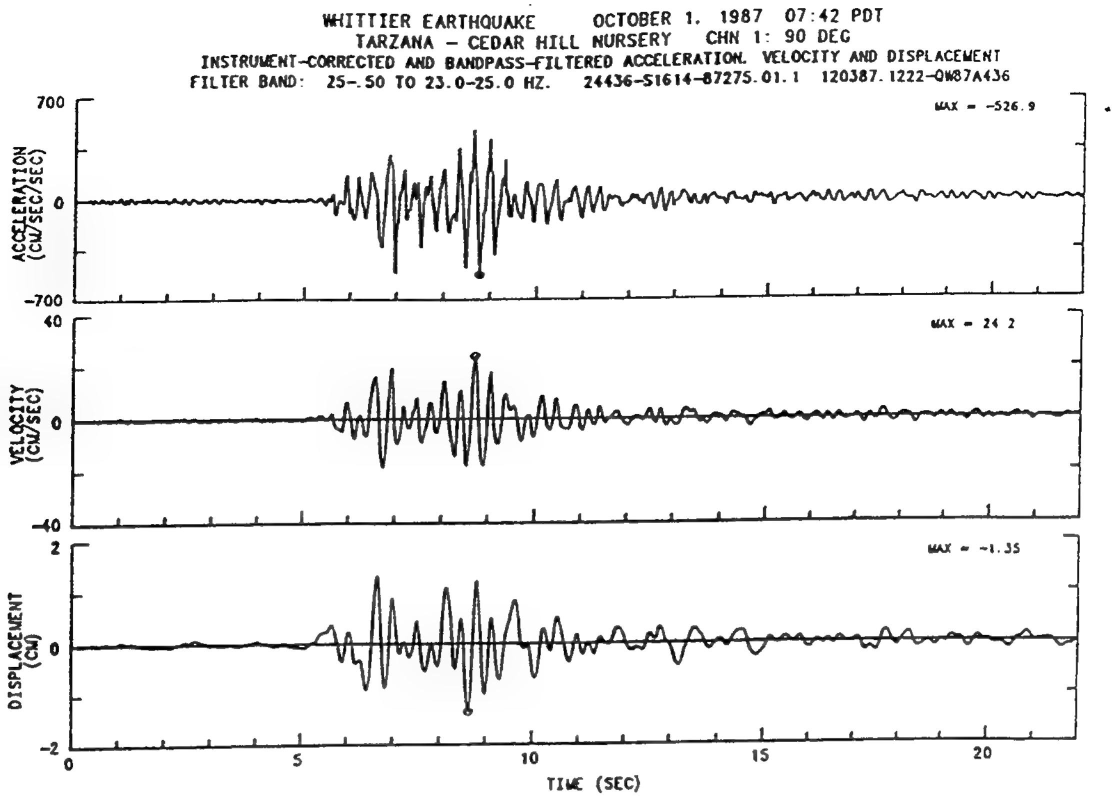
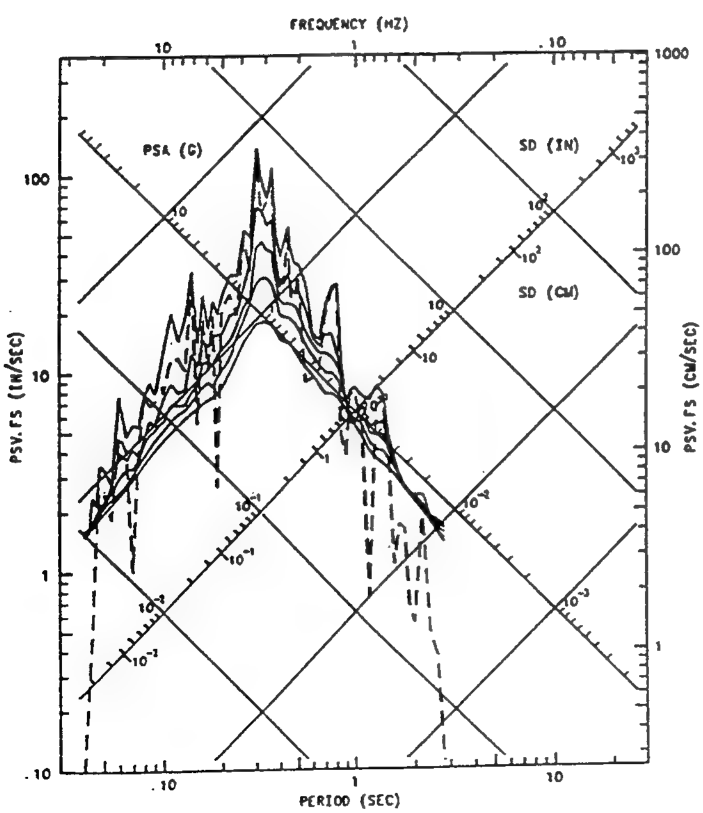


Figure 26. Morgan Hill Earthquake, April 24, 1984, 13:15 PST, CAL 229.

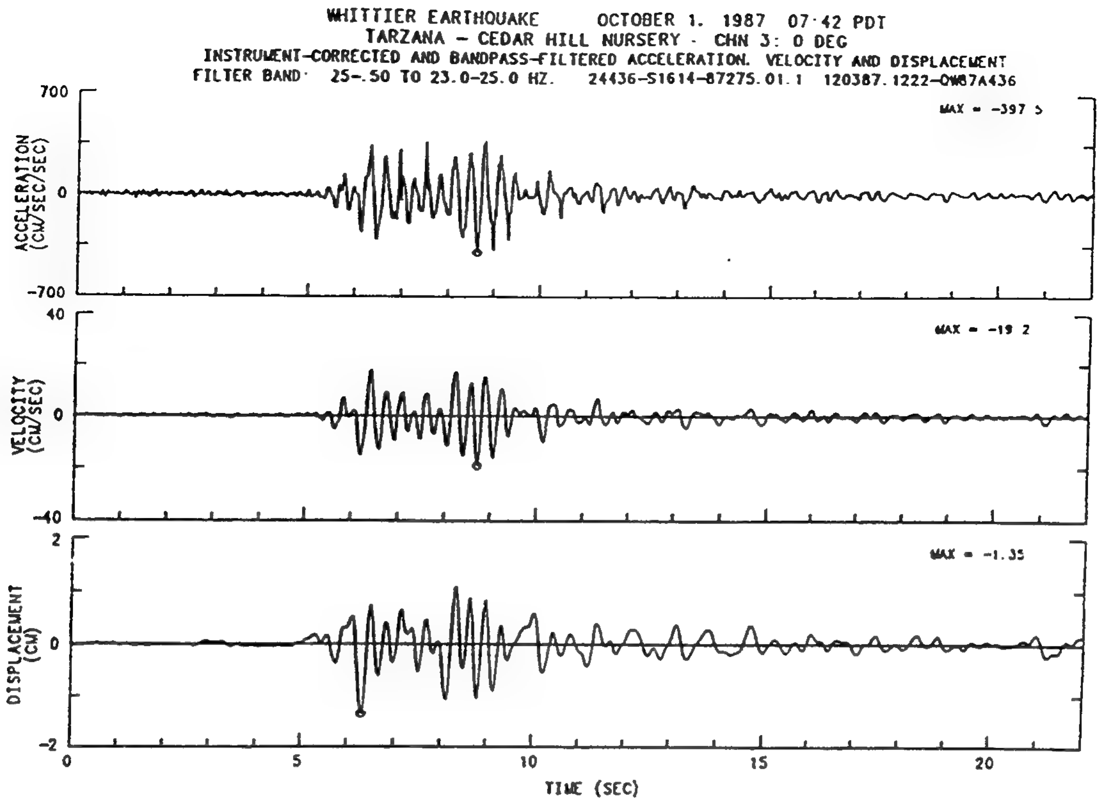


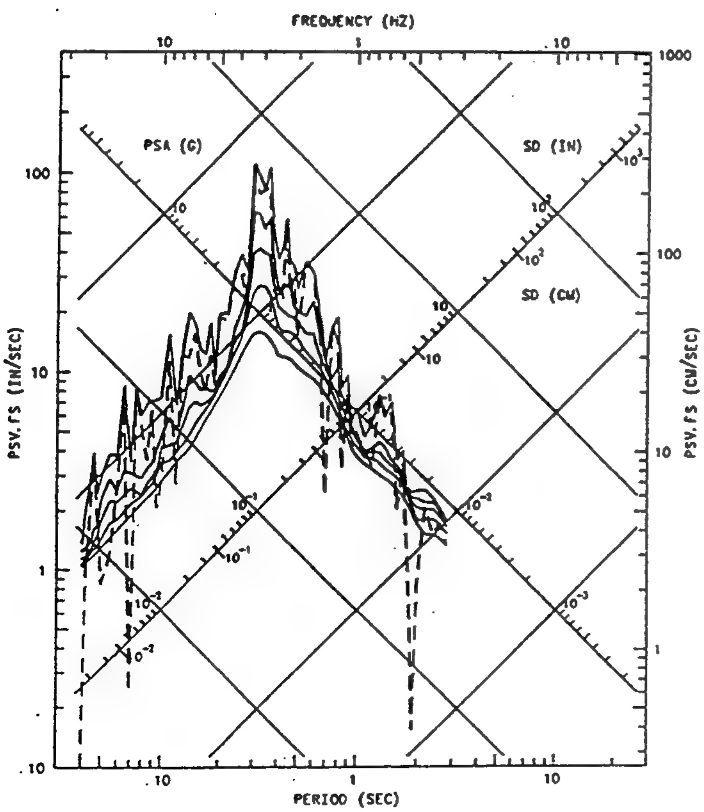


CDMG PRINTOUT

TARZANA - CEDAR HILL NURSERY
CHN 1: 90 DEG
ACCELEROGRAM BANDPASS-FILTERED WITH
RAMPS AT .25-.50 TO 23.0-25.0 HZ.
24436-S1614-87275.01.1
120387.1235-QW87A436
—— RESPONSE SPECTRA: PSV, PSA & SD
– – FOURIER AMPLITUDE SPECTRUM: FS
DAMPING VALUES: 0.2.5.10.20%

Figure 27. Whittier Earthquake, Oct 1, 1987, 07 42 PDT, CAL 270.

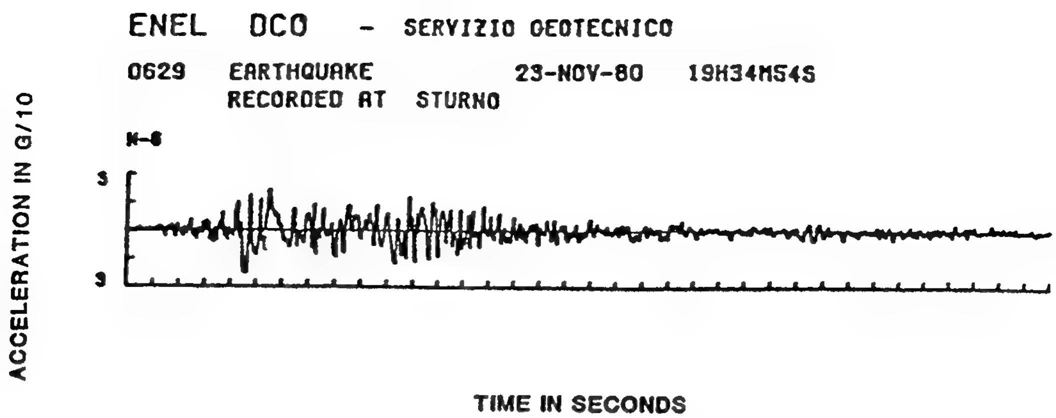




CDMG PRINTOUT

TARZANA - CEDAR HILL NURSERY
CHN 3: 0 DEG
ACCELEROGRAM BANDPASS-FILTERED WITH
RAMPS AT .25-.50 TO 23.0-25.0 HZ.
24436-S1614-87275.01.1
120387.1235-QW87A436
—— RESPONSE SPECTRA: PSV.PSA & SD
– – FOURIER AMPLITUDE SPECTRUM· FS
DAMPING VALUES: 0.2.5.10.20%

Figure 28. Whittier Earthquake, Oct 1, 1987, 07 42 PDT, CAL 271.



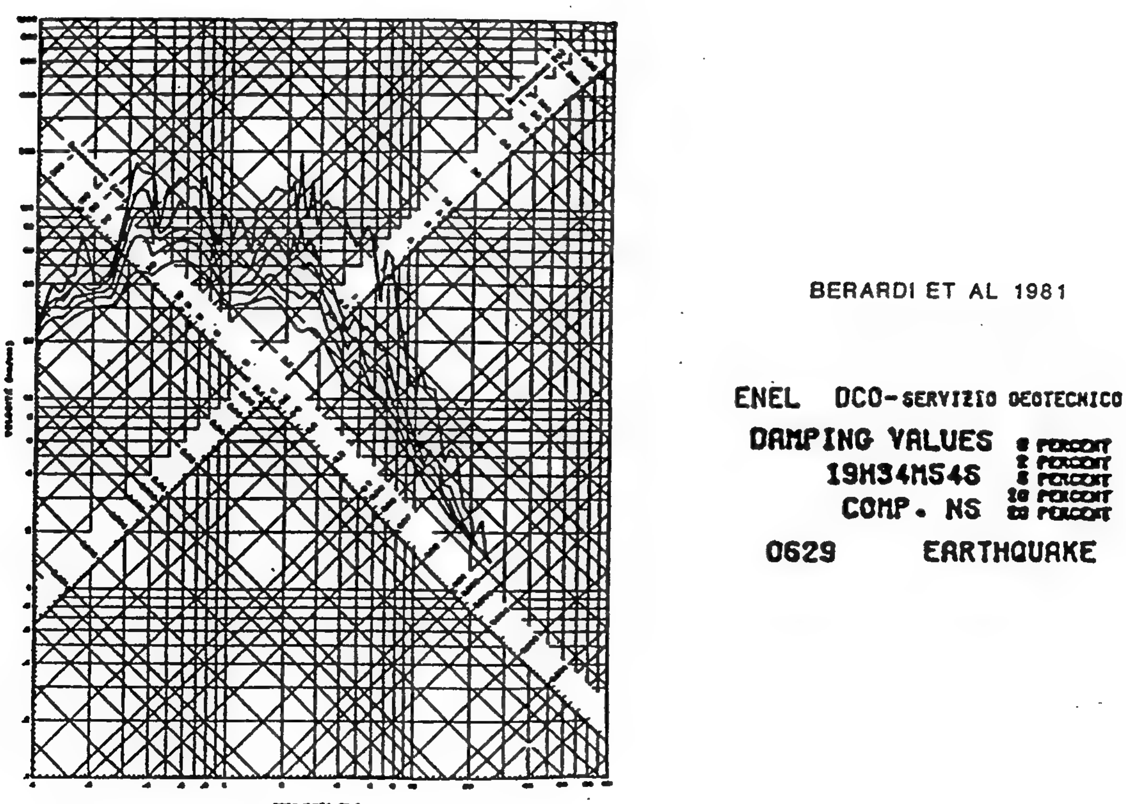
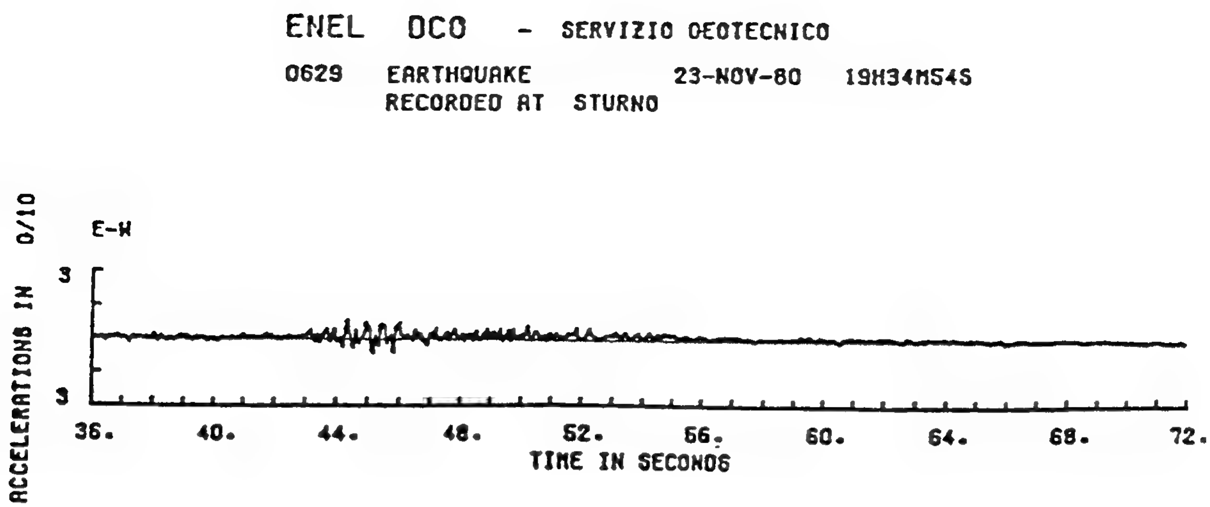


Figure 29. Sturno, Italy, ITA 20.



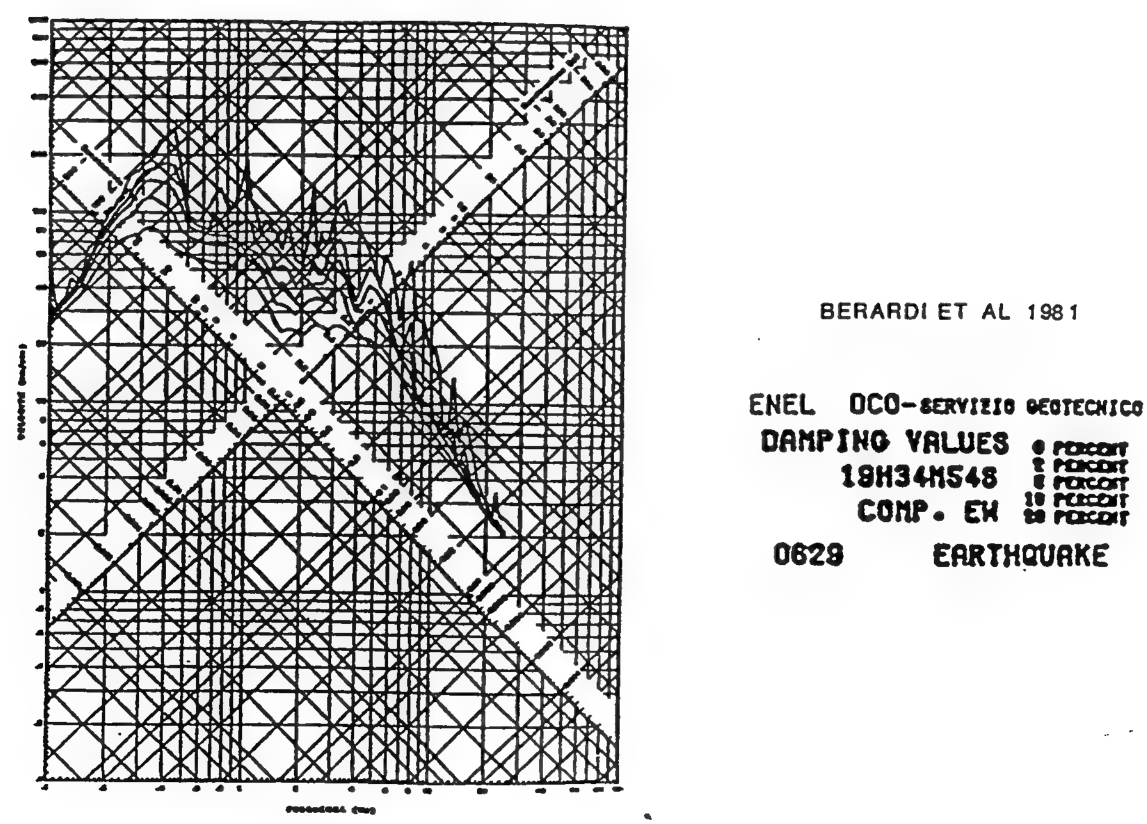


Figure 30. Sturno, Italy, ITA 21.

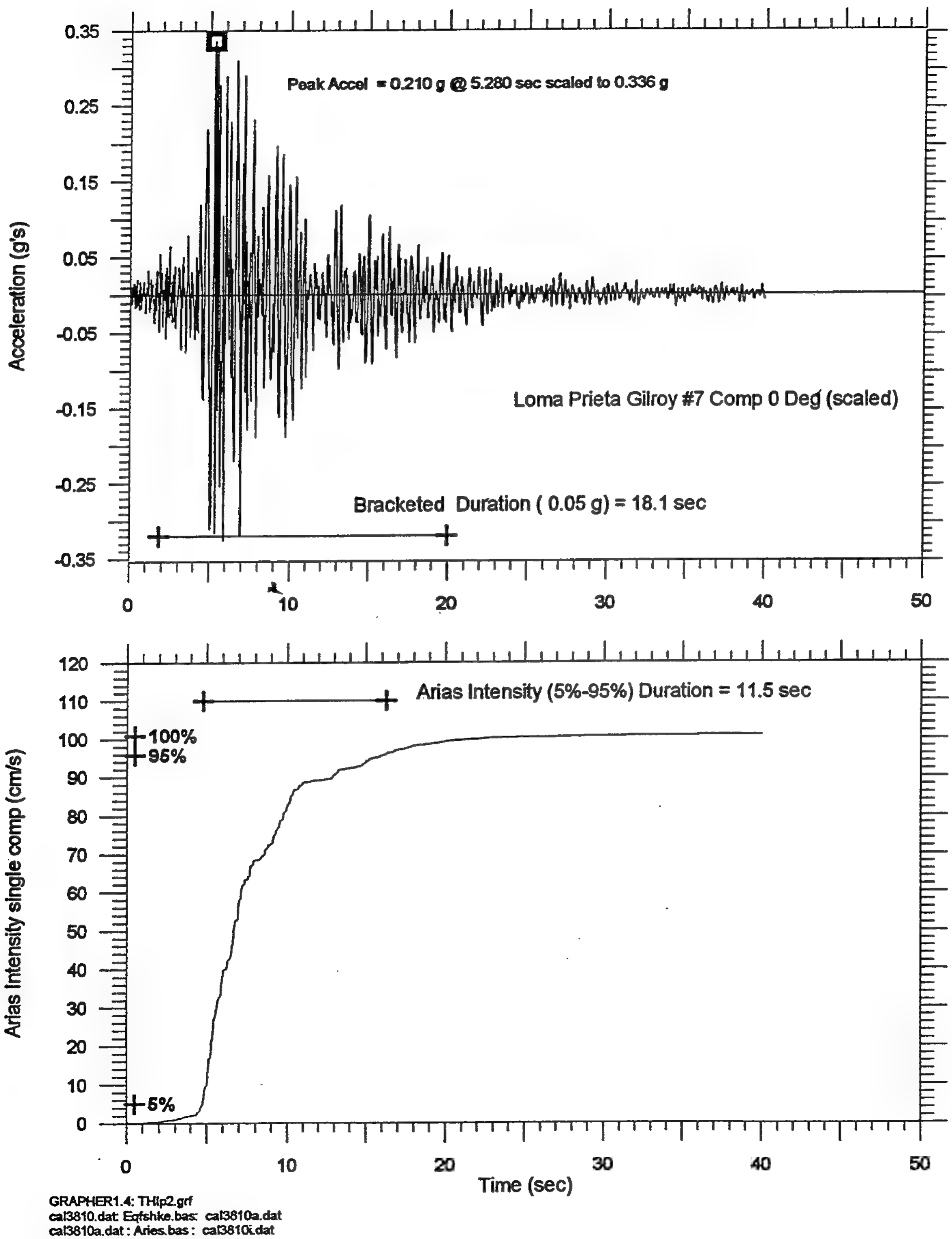


Figure 31. Loma Prieta Gilroy # 7, 0 degree component, scaled

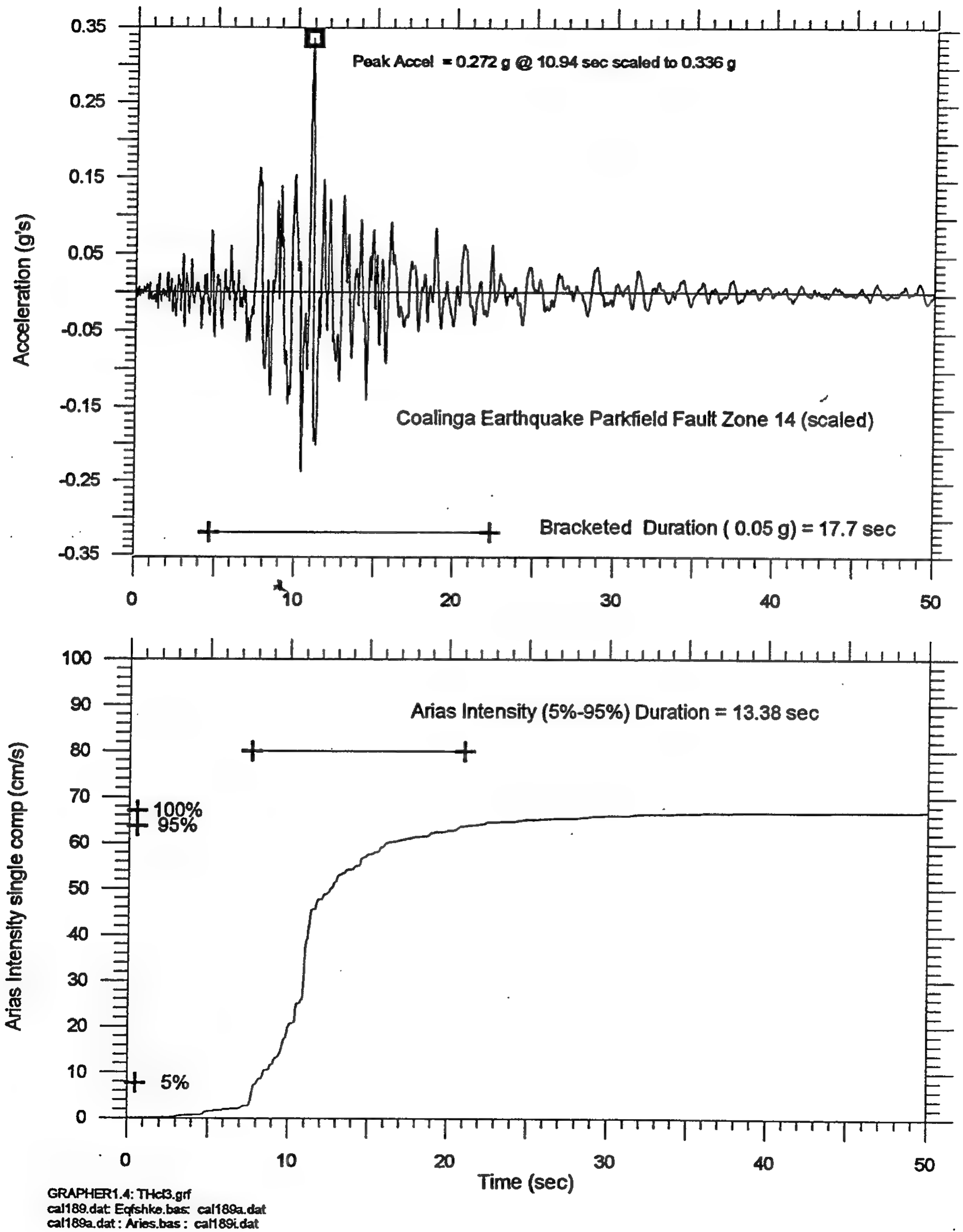


Figure 32. Coalinga earthquake, Parkfield Fault Zone 14, scaled

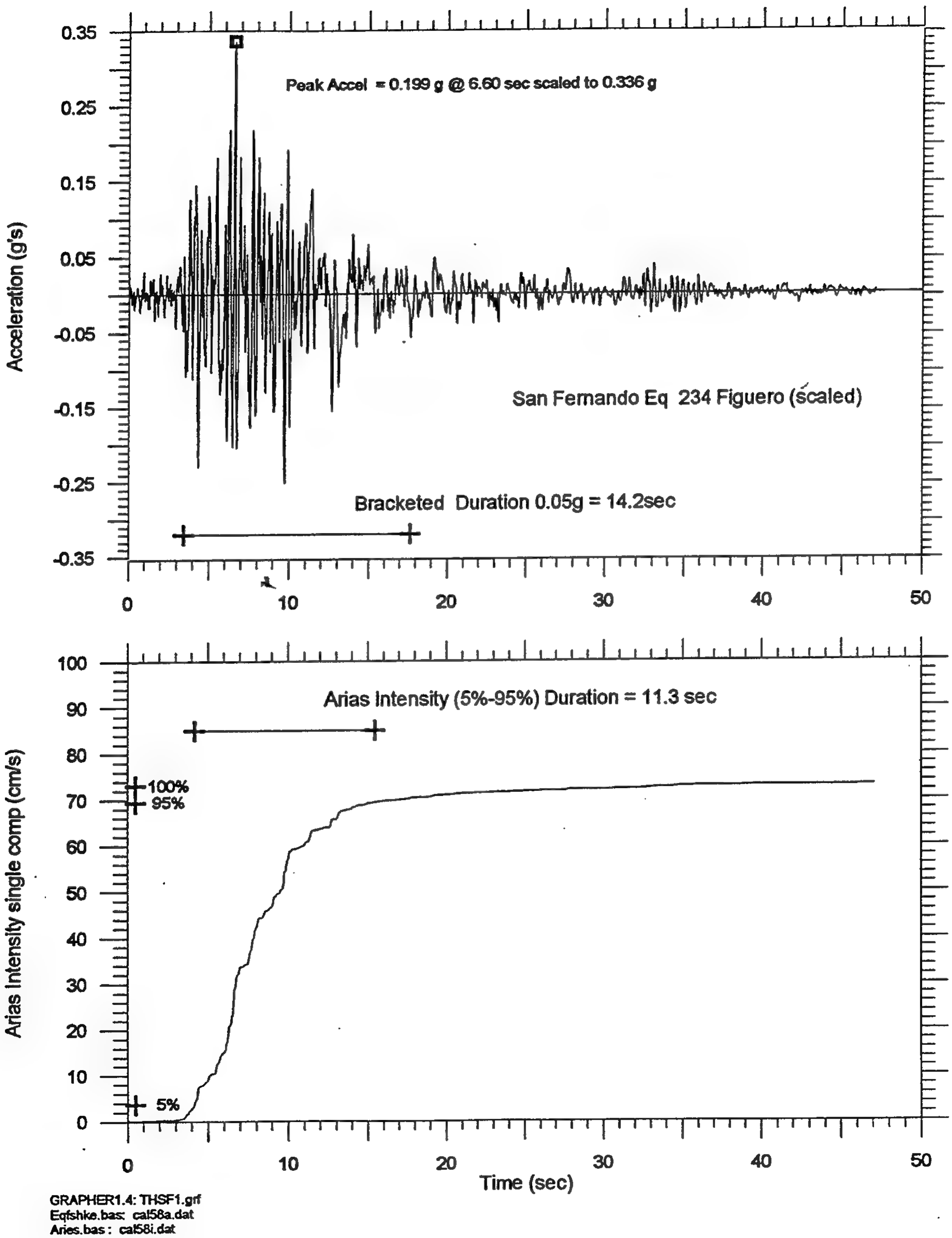


Figure 33. San Fernando earthquake, 234 Figuero, scaled

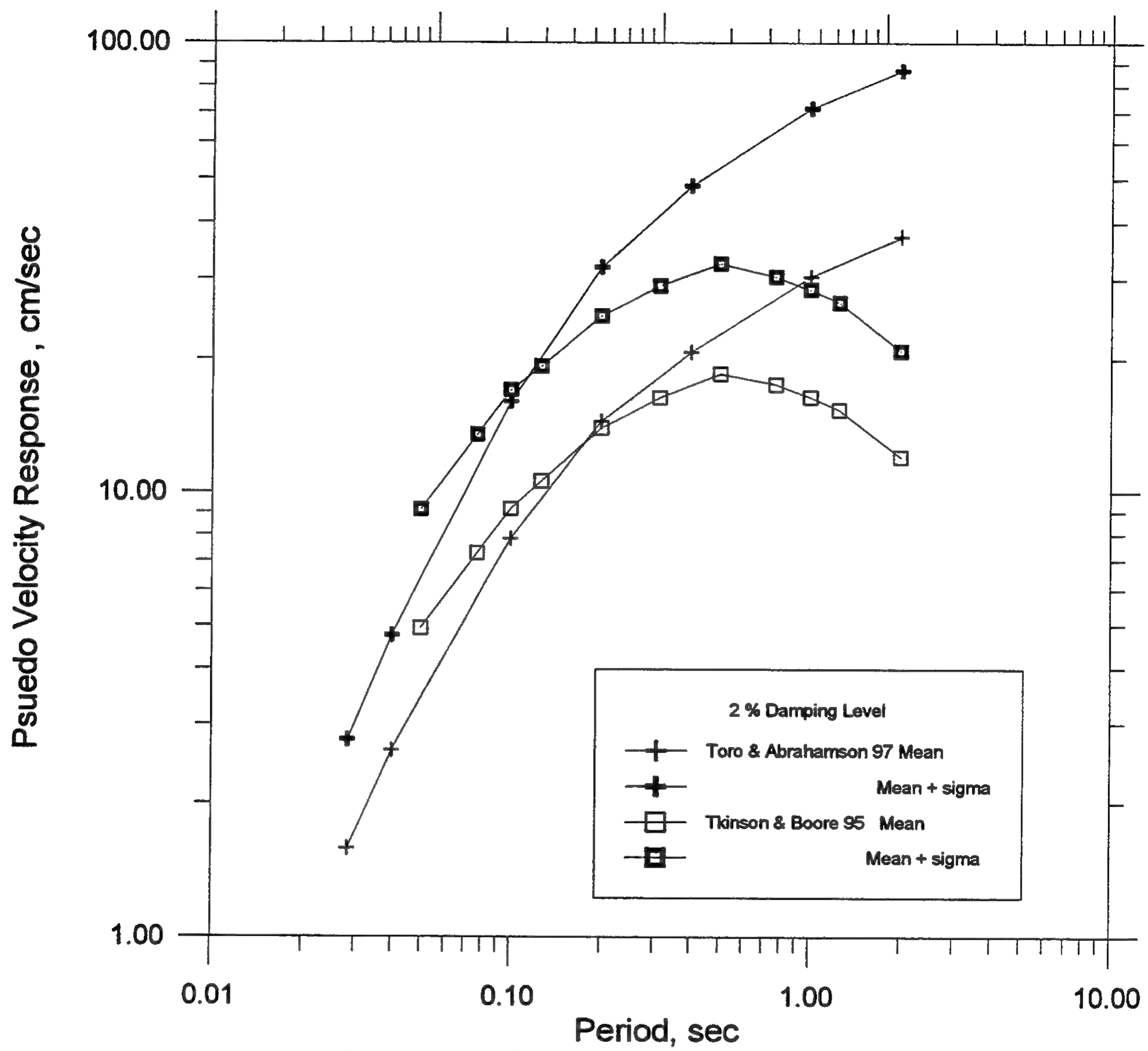


Figure 34a. Psuedo velocity response spectrum for 2 % damping for the Toro & Abrahamson and the Atkinson & Boore attenution relationships.

Graph: sphrsp2.grf
Data: sphab95.dat, sphta97.dat
sphtad02(10,15).dat
sphab20(10,15).dat

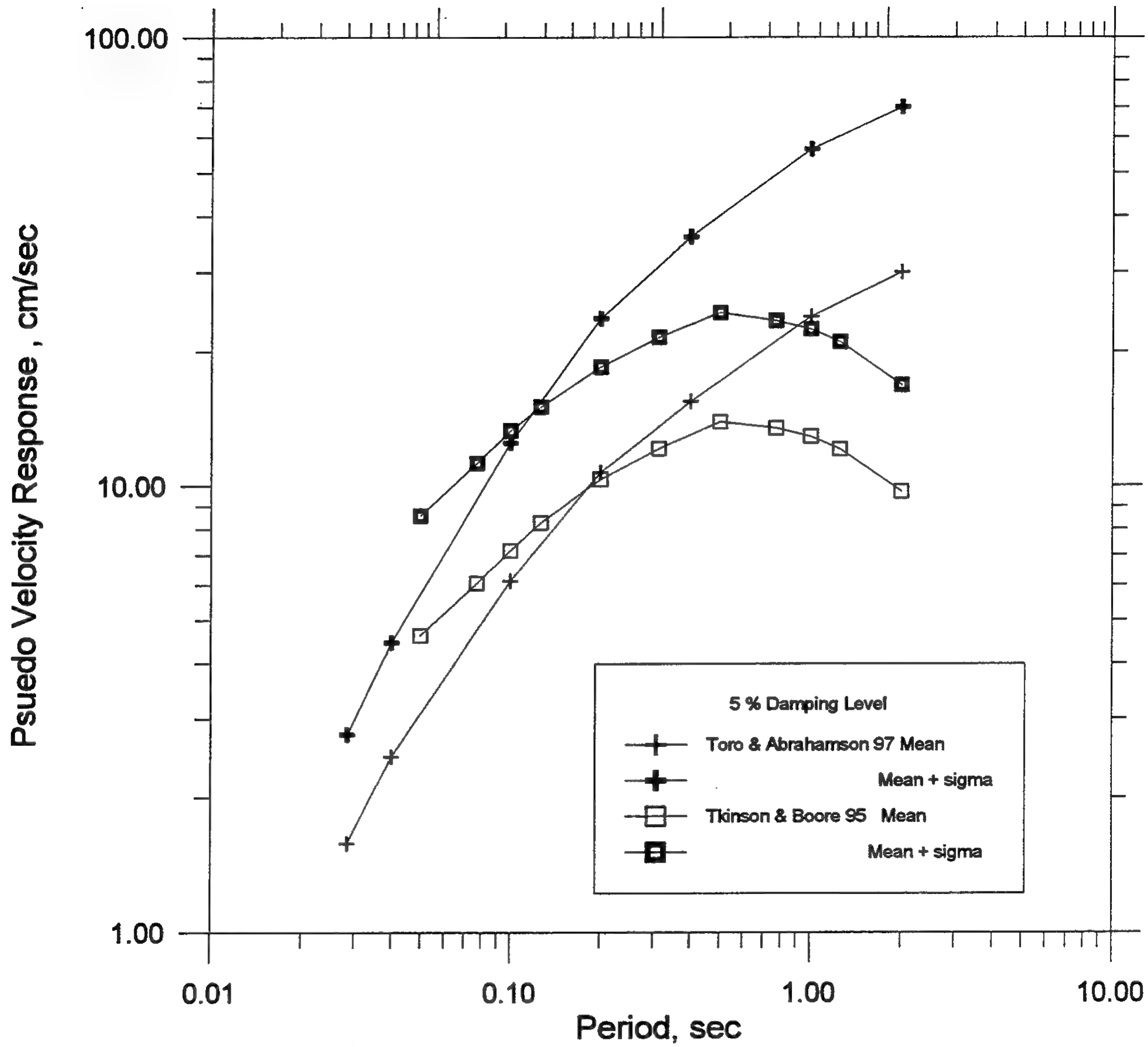


Figure 34b. Psuedo velocity response spectrum for 5 % damping for the Toro & Abrahamson and the Atkinson & Boore attenution relationships.

Graph: sphrsp5.grf
Data: sphab95.dat, sphta97.dat

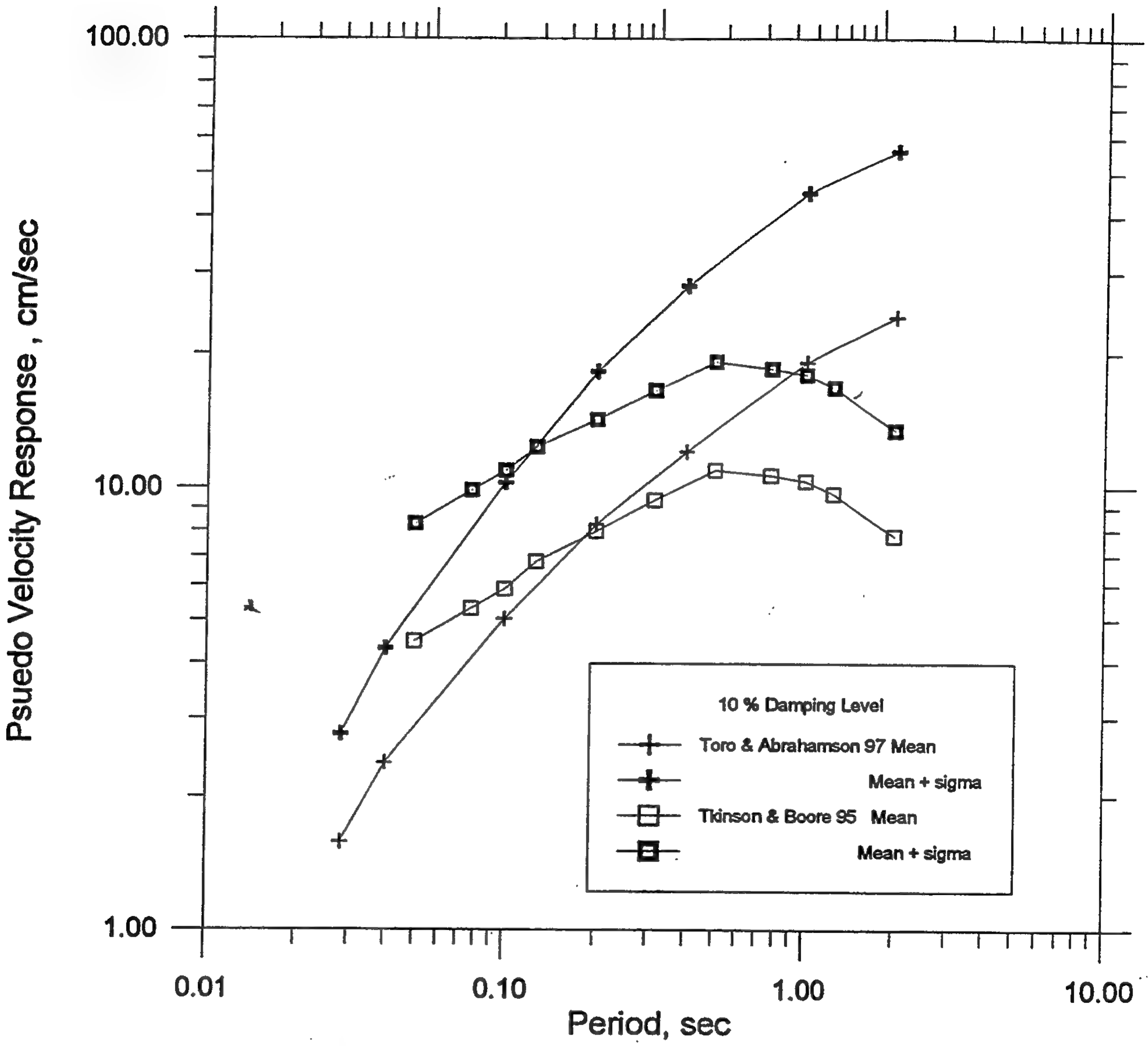


Figure 34c. Psuedo velocity response spectrum for 10 % damping for the Toro & Abrahamson and the Atkinson & Boore attenution relationships.

Graph: sphrsp10.grf
Data: sphta10.dat, sphab10.dat

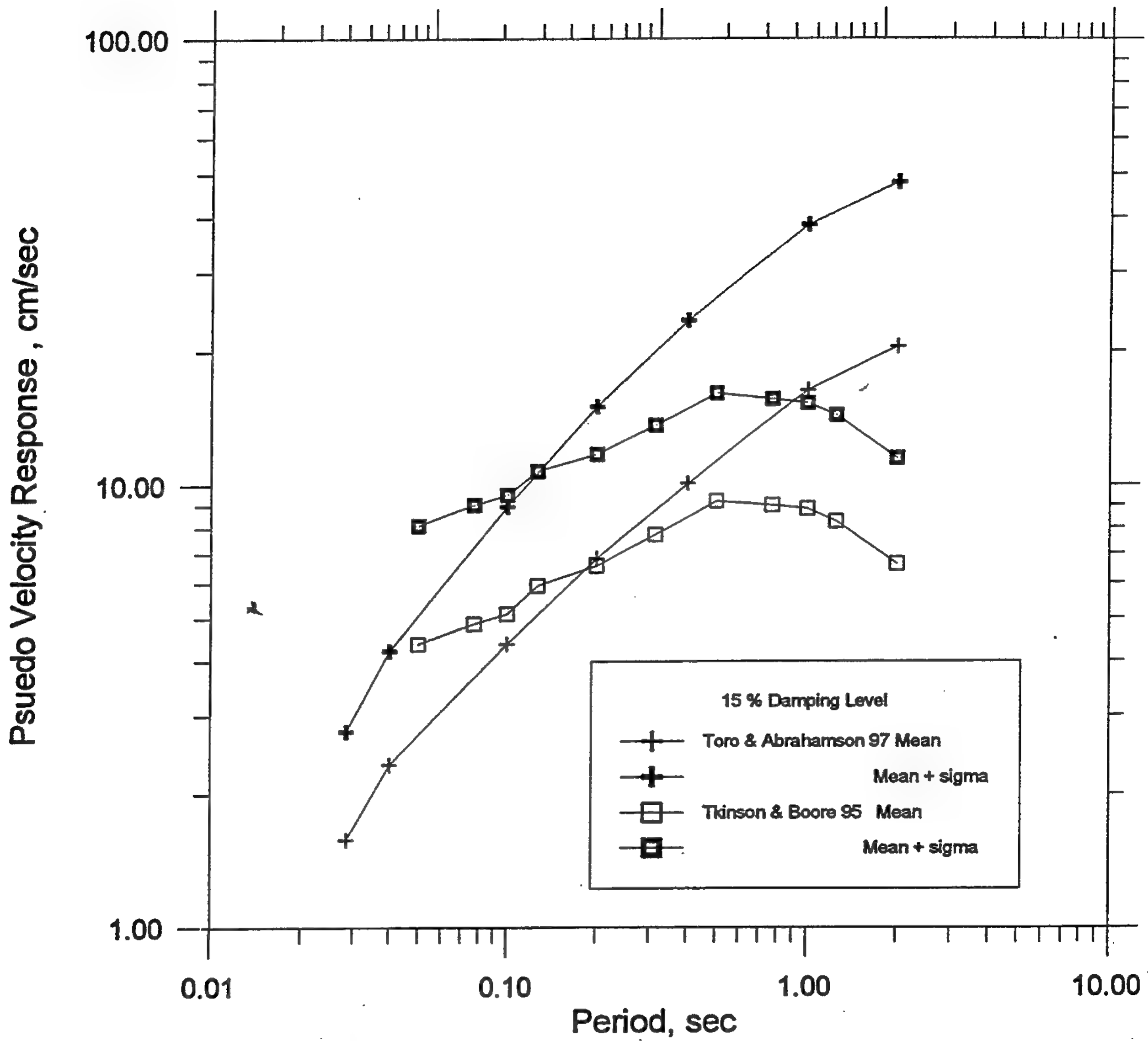


Figure 34d. Psuedo velocity response spectrum for 15 % damping for the Toro & Abrahamson and the Atkinson & Boore attenution relationships.

Graph: sphrsp15.grf
Data: sphta15.dat, sphab15.dat

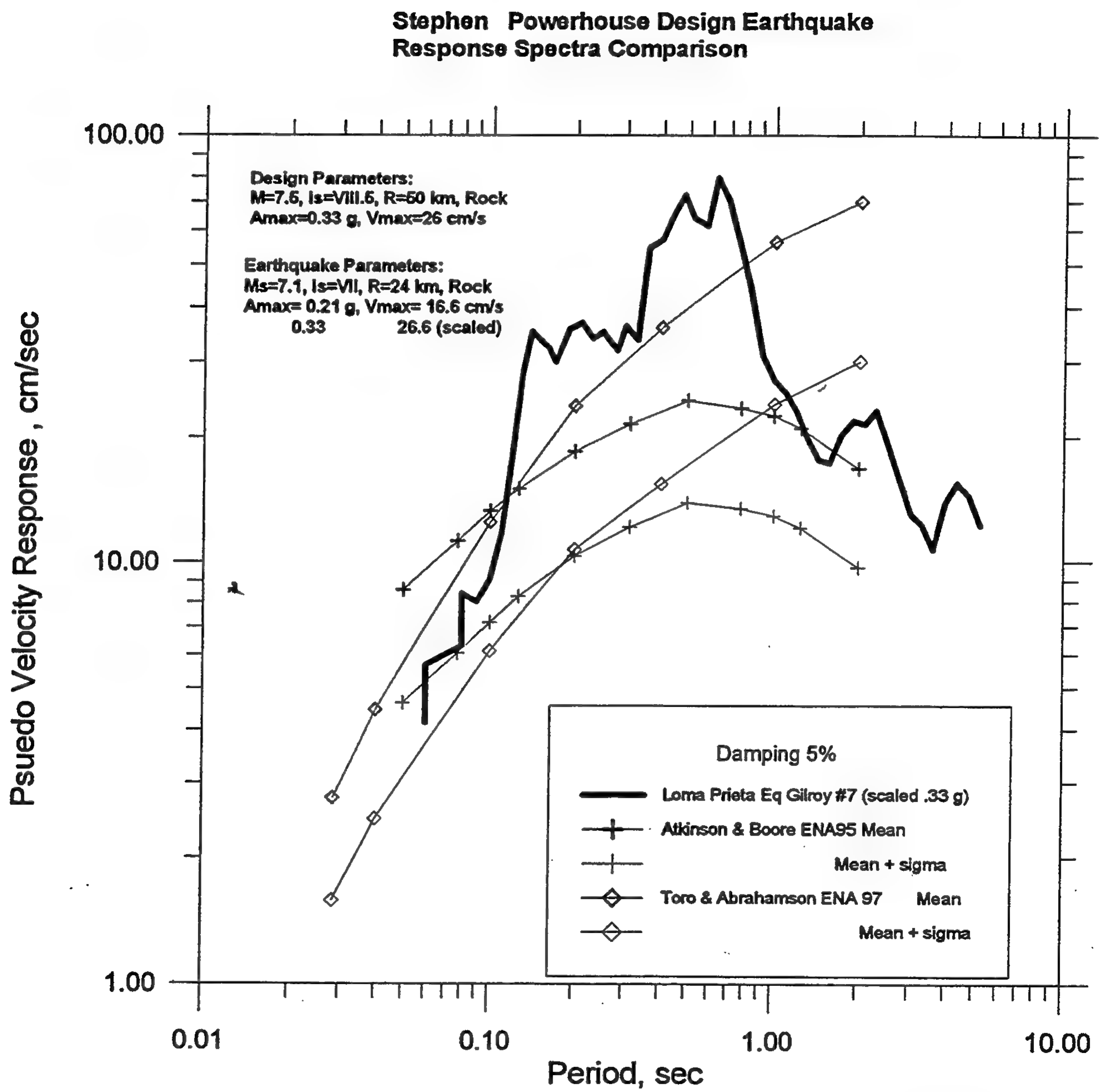


Figure 35. MCE and Loma Prieta Gilroy # 7 response spectra (5 % damping)

GRAPHER1.4: sphr3810.grf
Gshkr.bas: c3819rs.dat
Gestx.bas: sphab95.dat, sphta97.dat

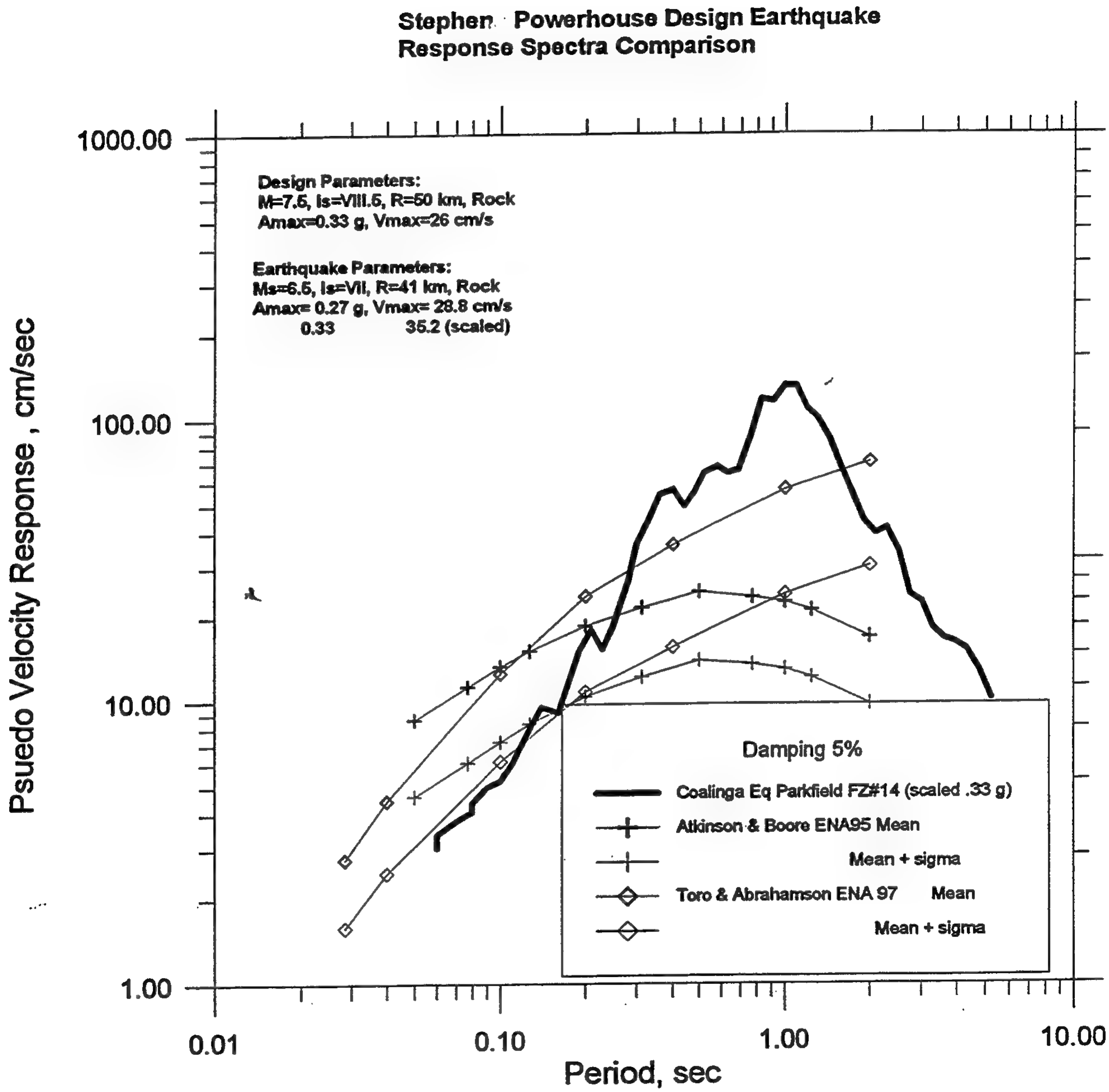


Figure 36. MCE and Coalinga, Fault Zone 14 response spectra (5 % damping)

GRAPHER1.4: sphr189.grf
Gshkr.bas: c189rs.dat
Gestx.bas: sphab95.dat, sphta97.dat

Stephen Powerhouse Design Earthquake
Response Spectra Comparison

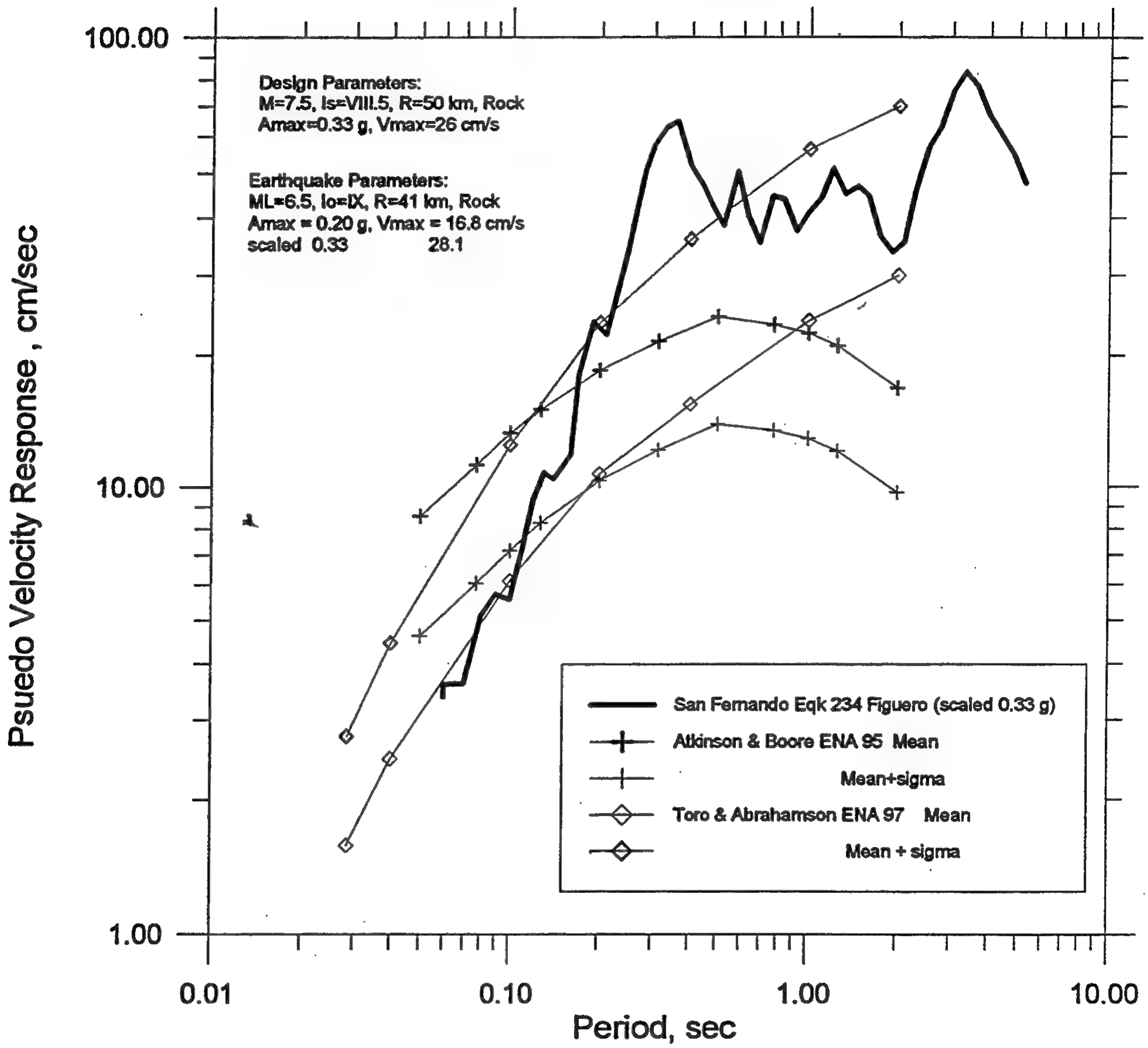
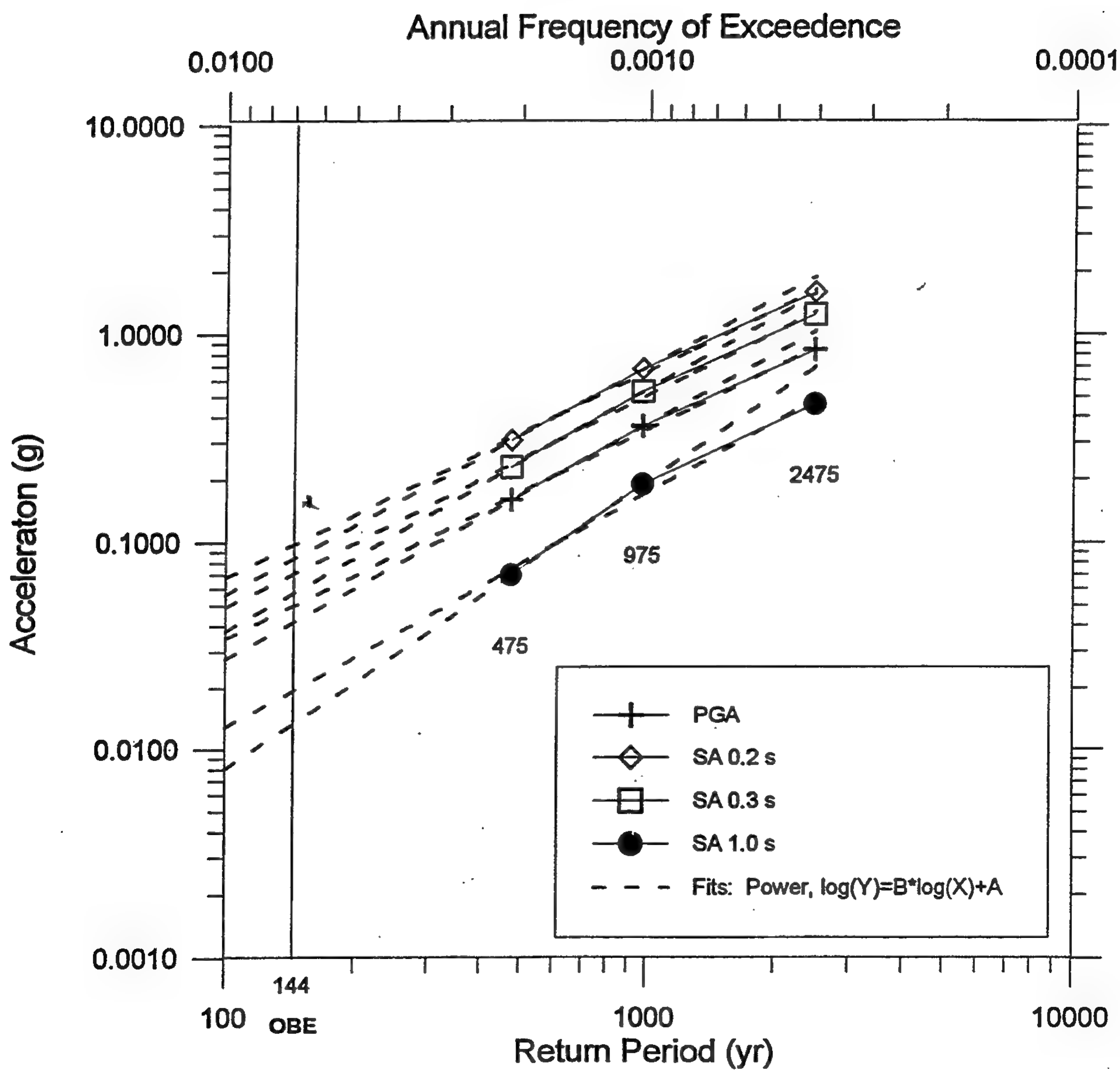


Figure 37. MCE and San Fernando earthquake, 234 Figuero response spectra (5 % damping)

GRAPHER1.4: sphrc058.grf
Gshkr.bas: cal58rs.dat
Gestx.bas: sphab95.dat, sphta97.dat

Probabilistic Seismic Hazard Curve
St. Stephen Powerhouse, Cooper River Diversion Project, GA
NEHRP National Hazard Maps November 1996
Soil Profile B-C



GRAPHER1.4 : sphprob.grf
probhz1.dat

Figure 38. USGS Probabilistic seismic hazard curves for St. Stephen Powerhouse site

Charlshz Chart 2

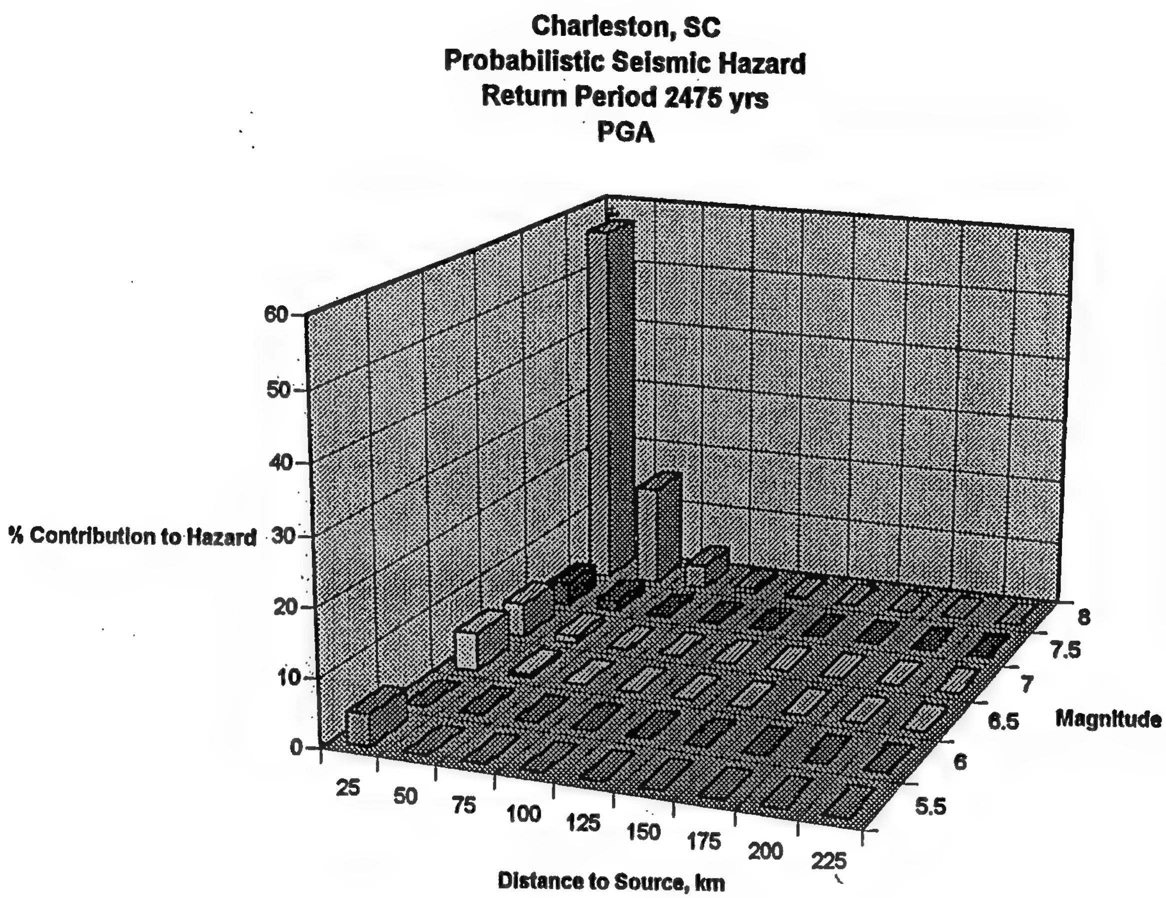


Figure 39. Deaggregated PGA hazard, Charleston, South Carolina

Charlshz Chart 3

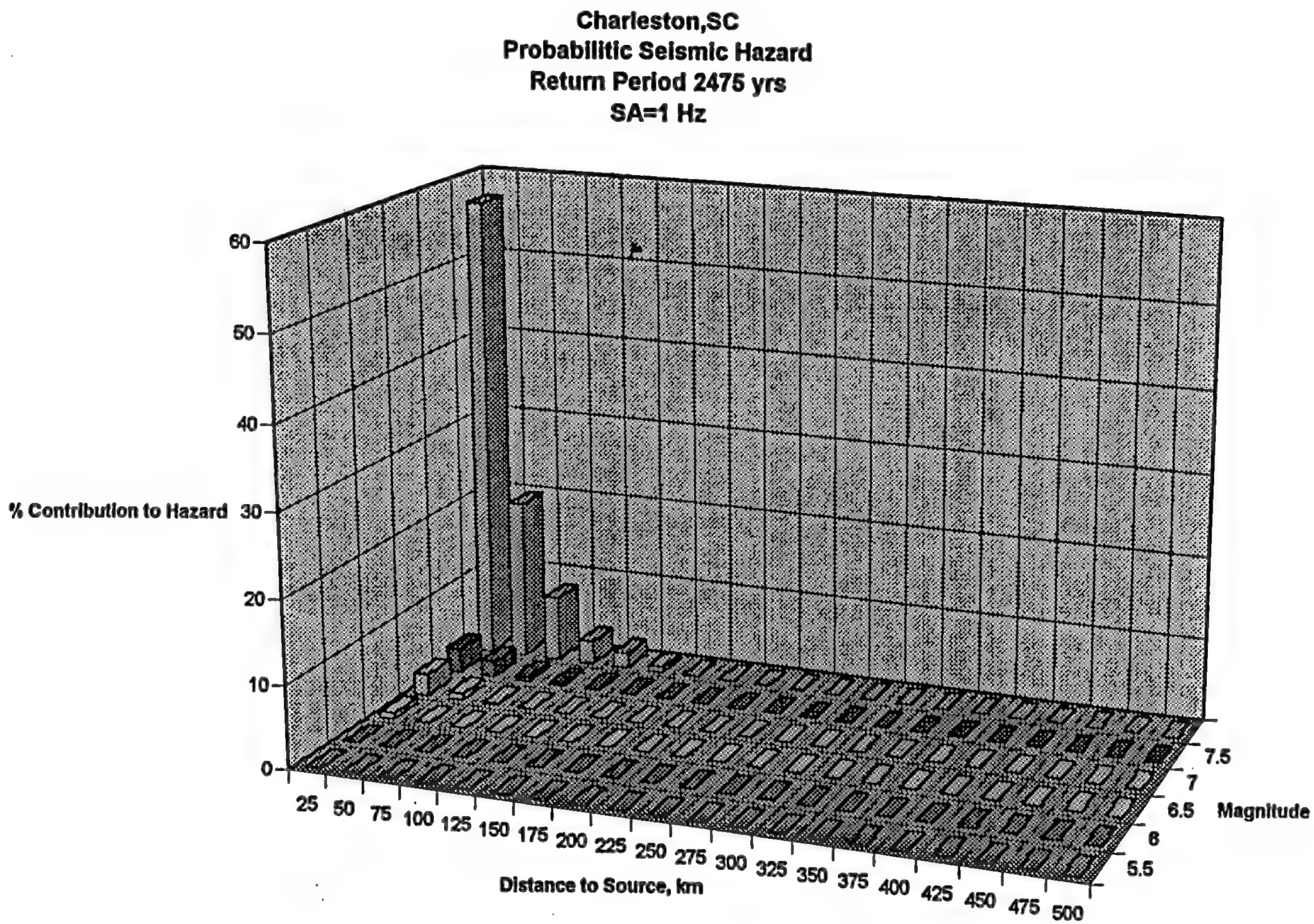


Figure 40. Deaggregated SA(1 Hz) hazard, Charleston, South Carolina

Charlshz Chart 4

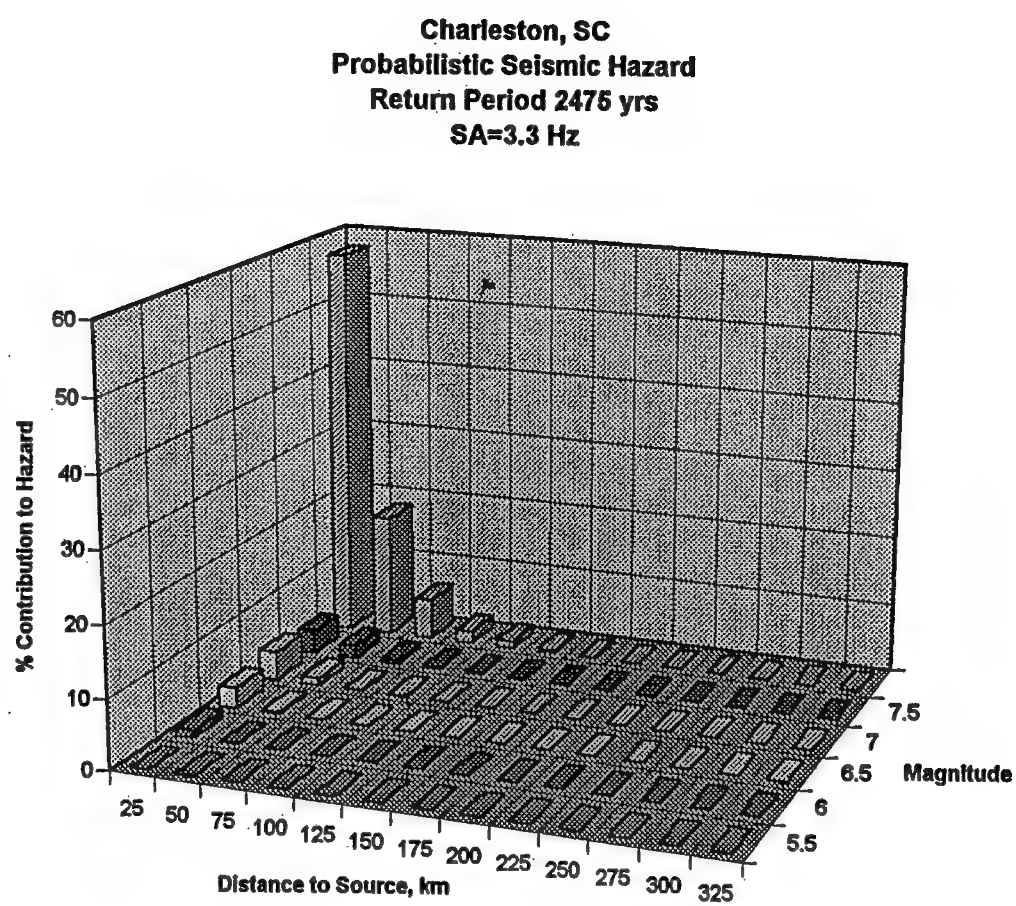


Figure 41. Deaggregated SA(3.3 Hz) hazard, Charleston, South Carolina

Charlshz Chart 5

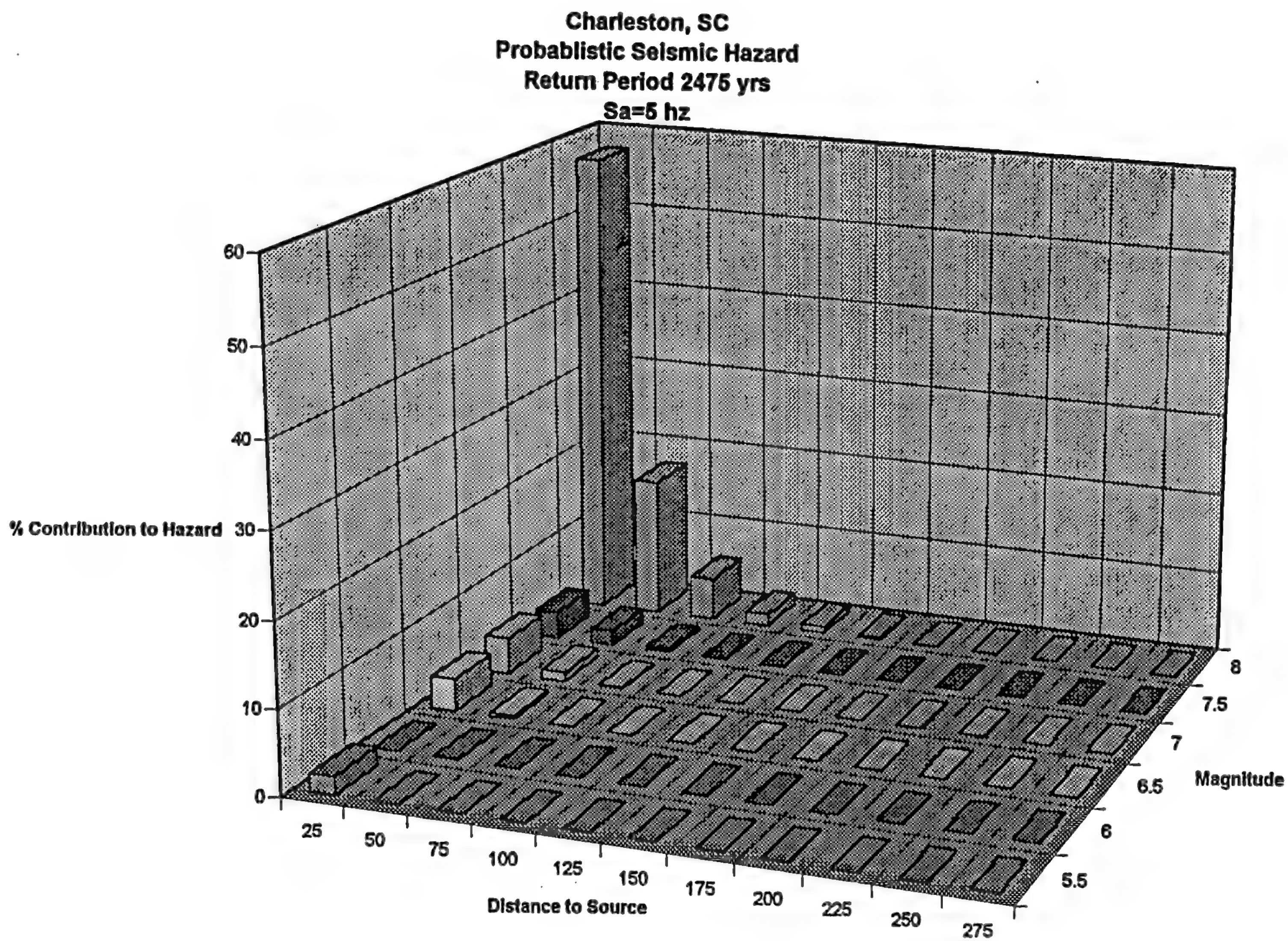


Figure 42. Deaggregated SA(5 Hz) hazard, Charleston, South Carolina

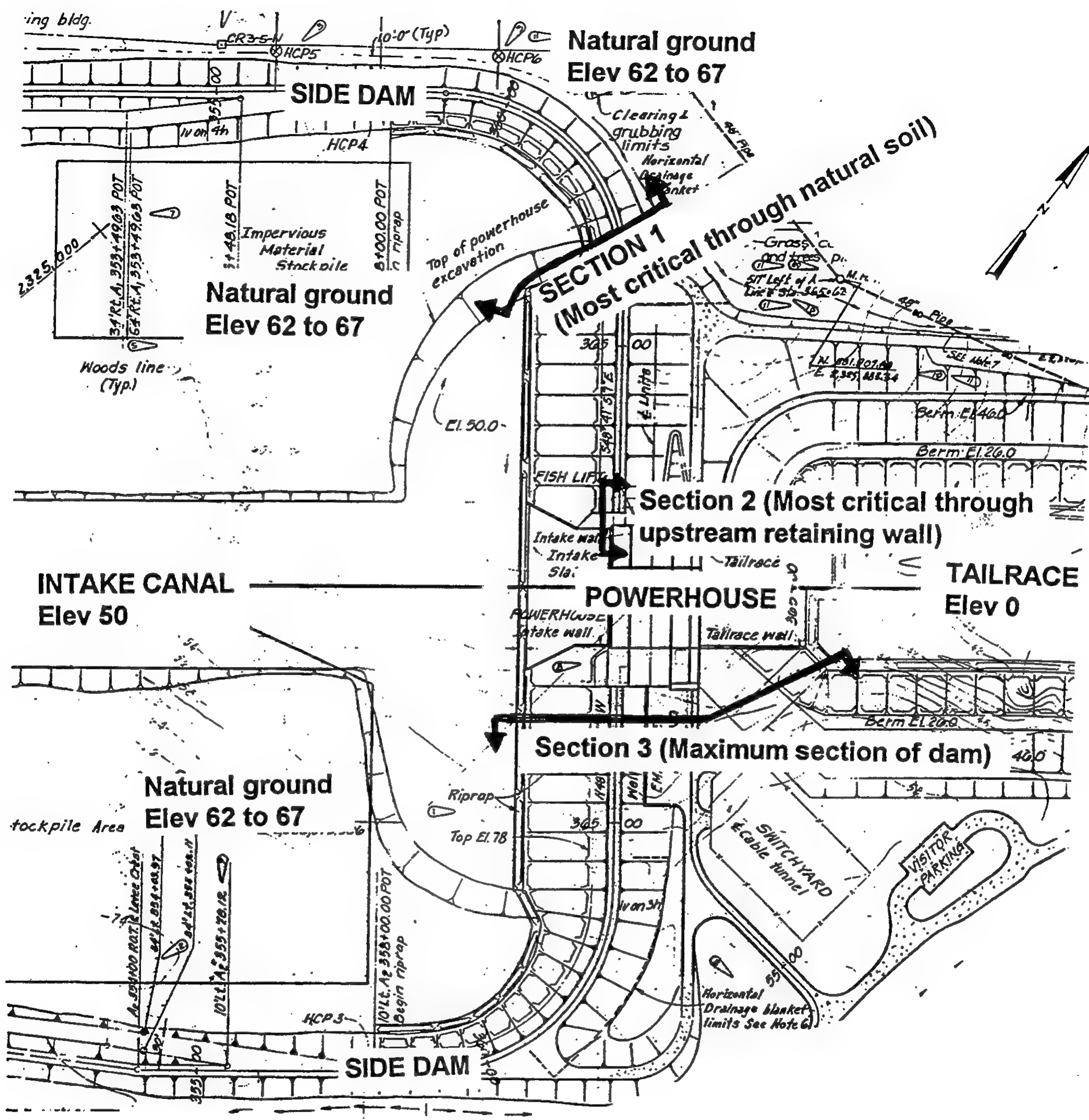


Figure 43. Plan of St. Stephen Powerhouse Project

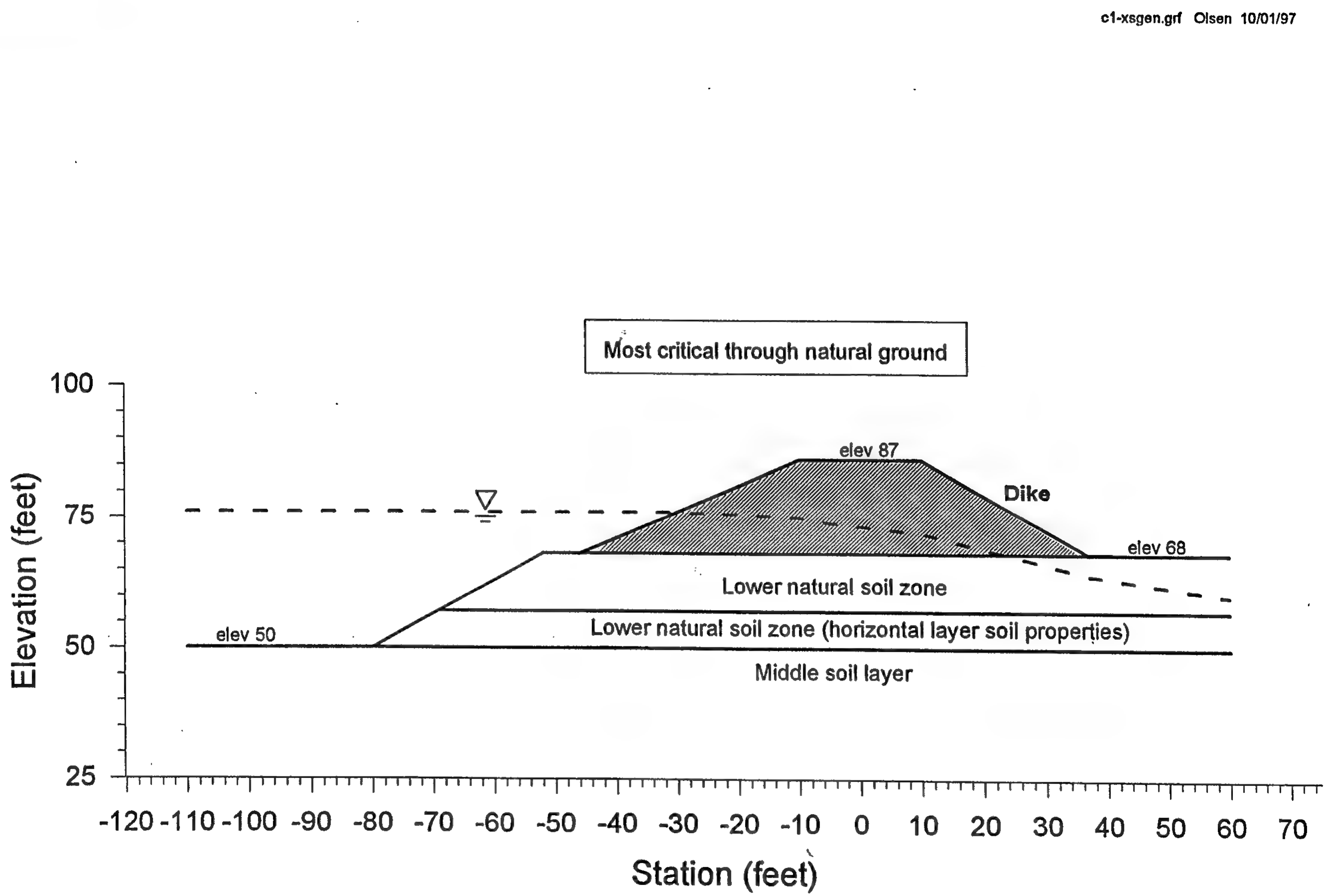


Figure 44. Section 1, as idealized, embankment on natural foundation deposit

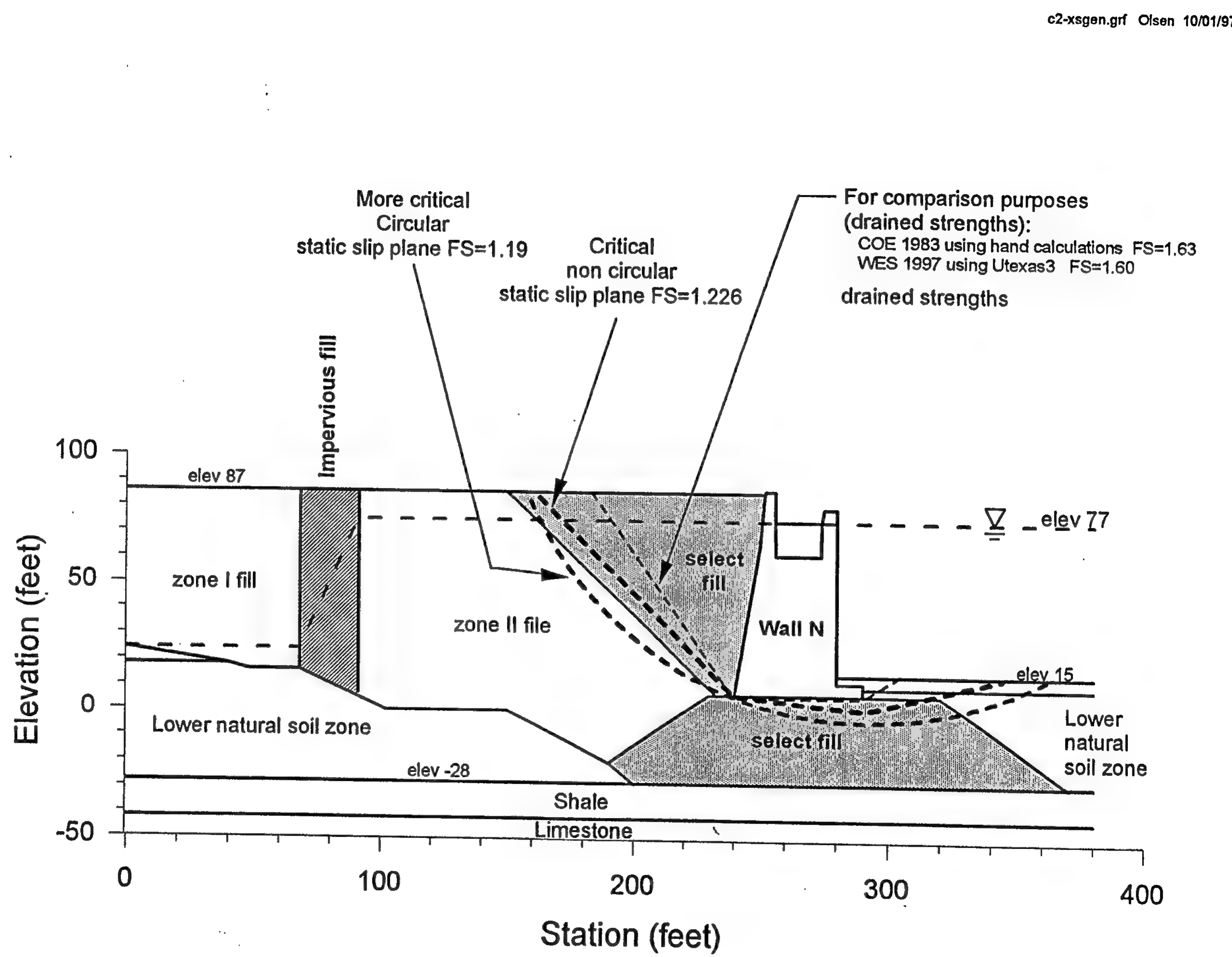


Figure 45. Section 2, as idealized, upstream retaining wall

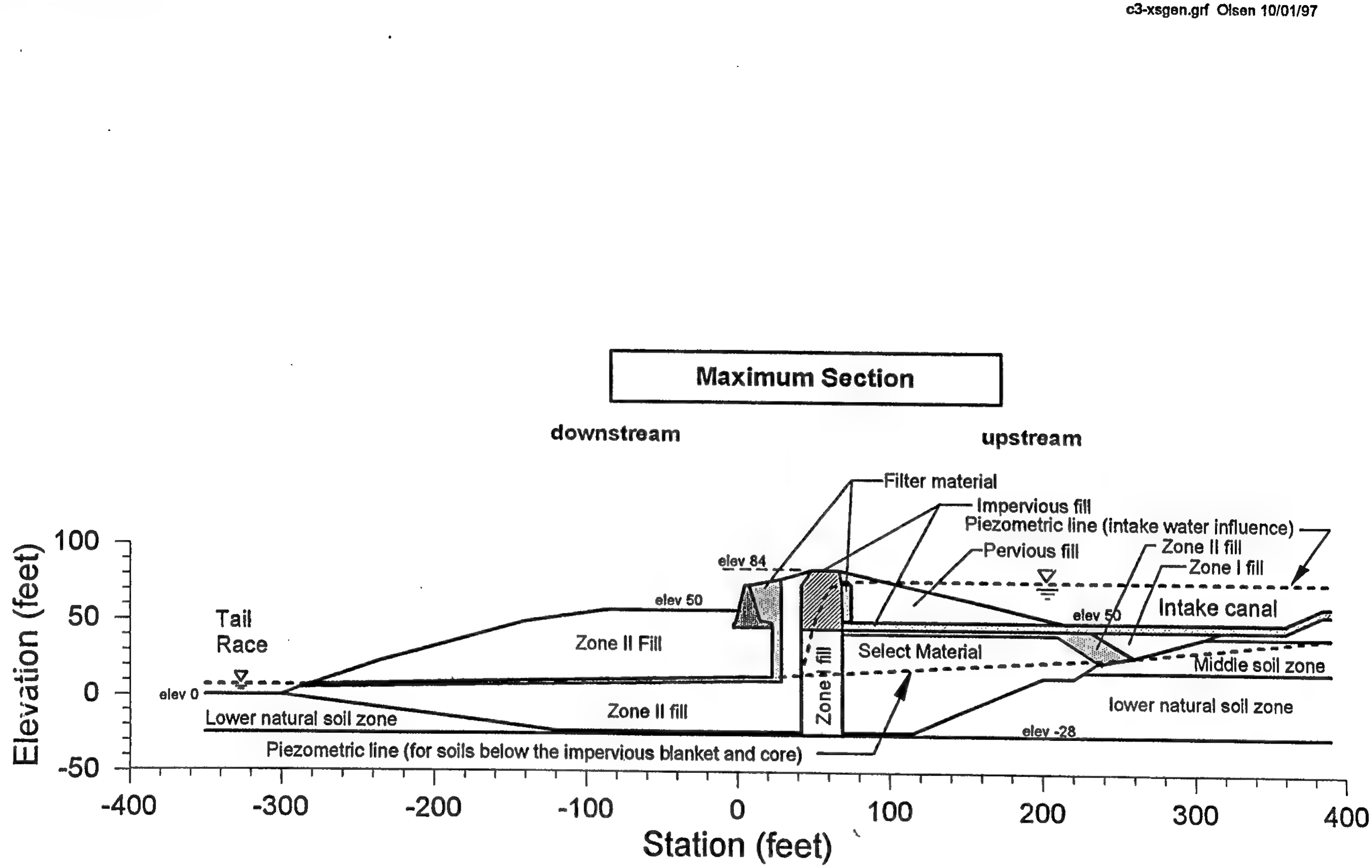


Figure 46. Section 3, as idealized, maximum section of embankment dam

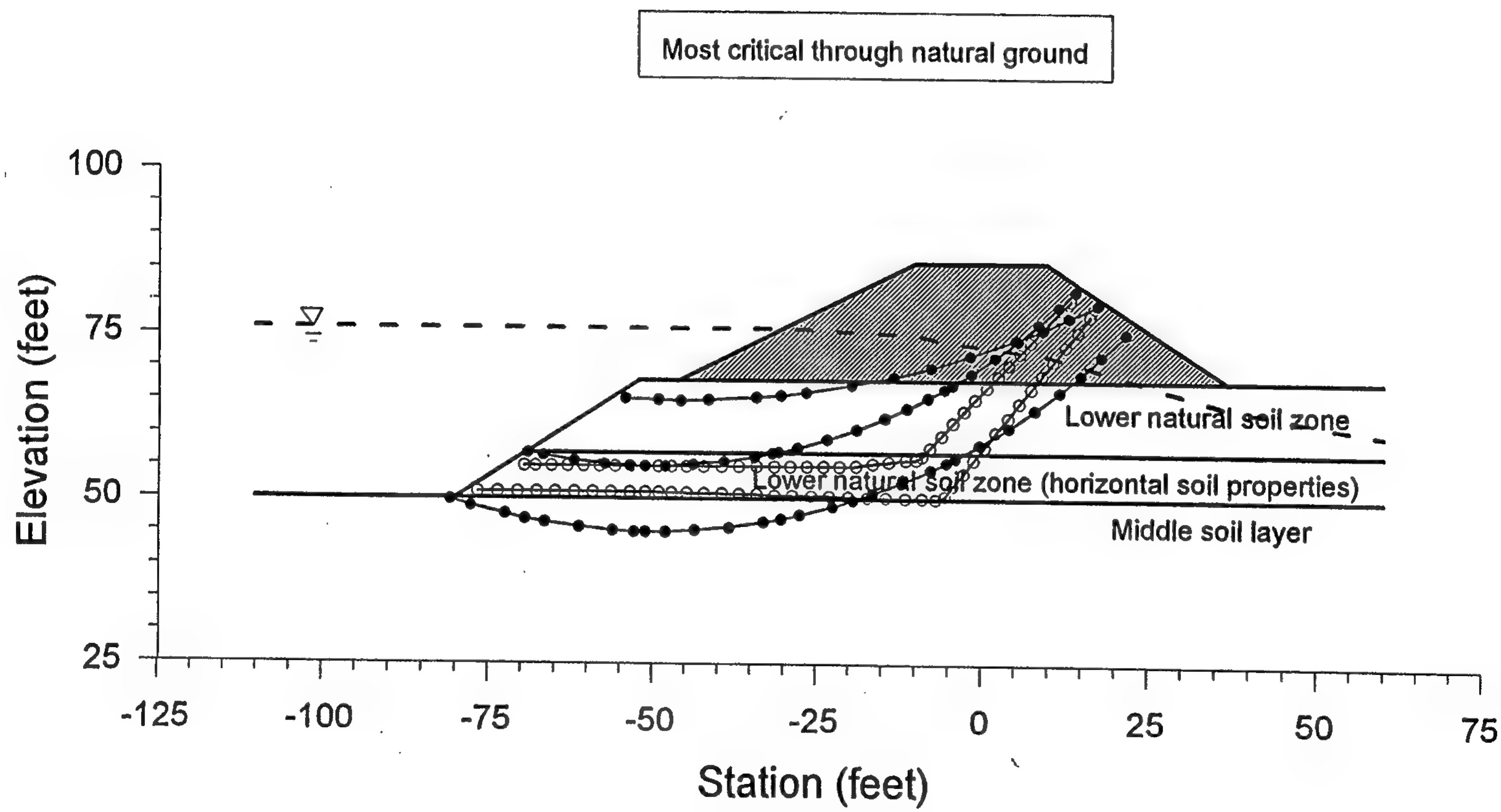


Figure 47. Yield acceleration slip surfaces, Section 1

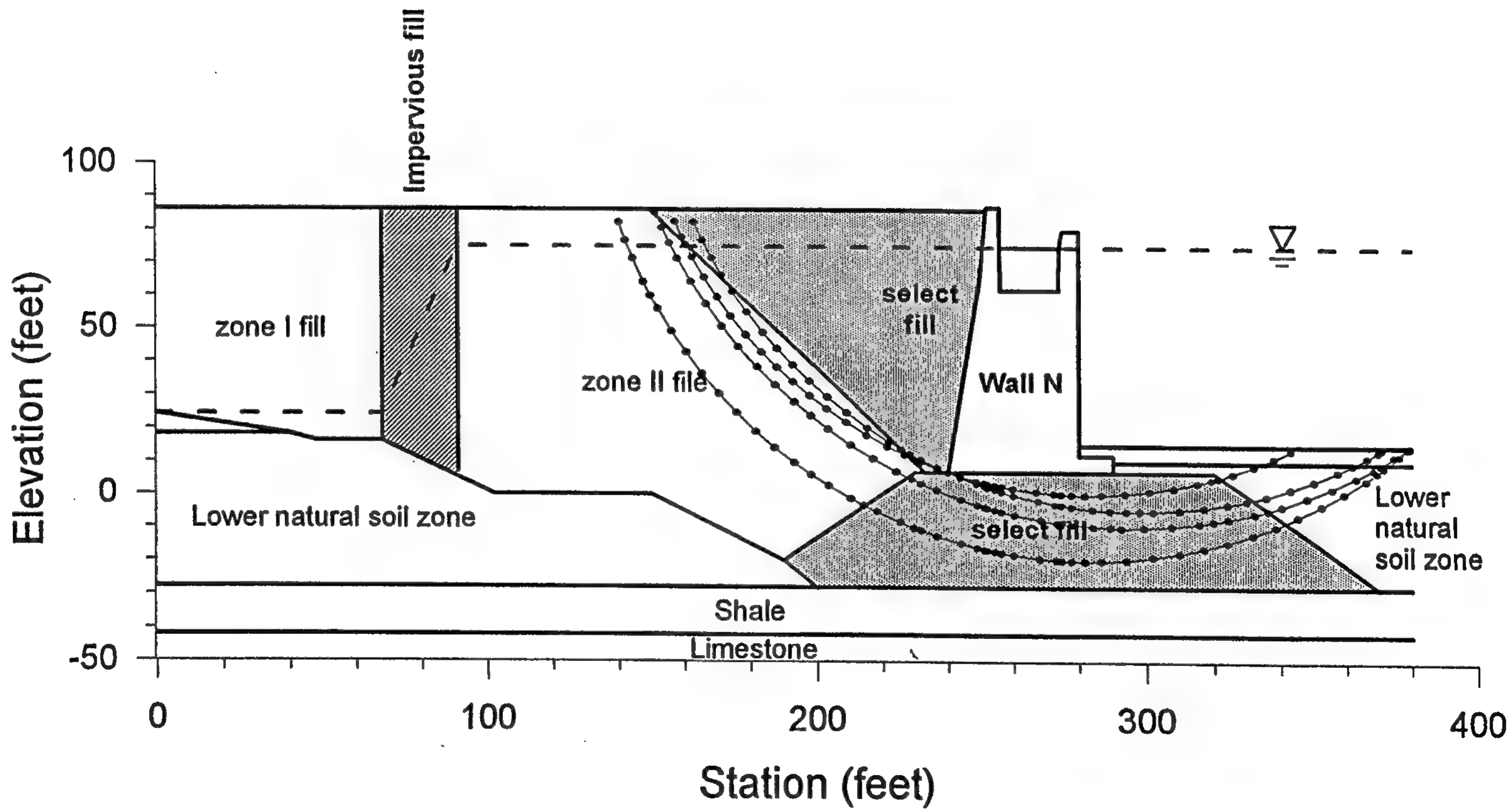


Figure 48. Yield acceleration slip surfaces, Section 2

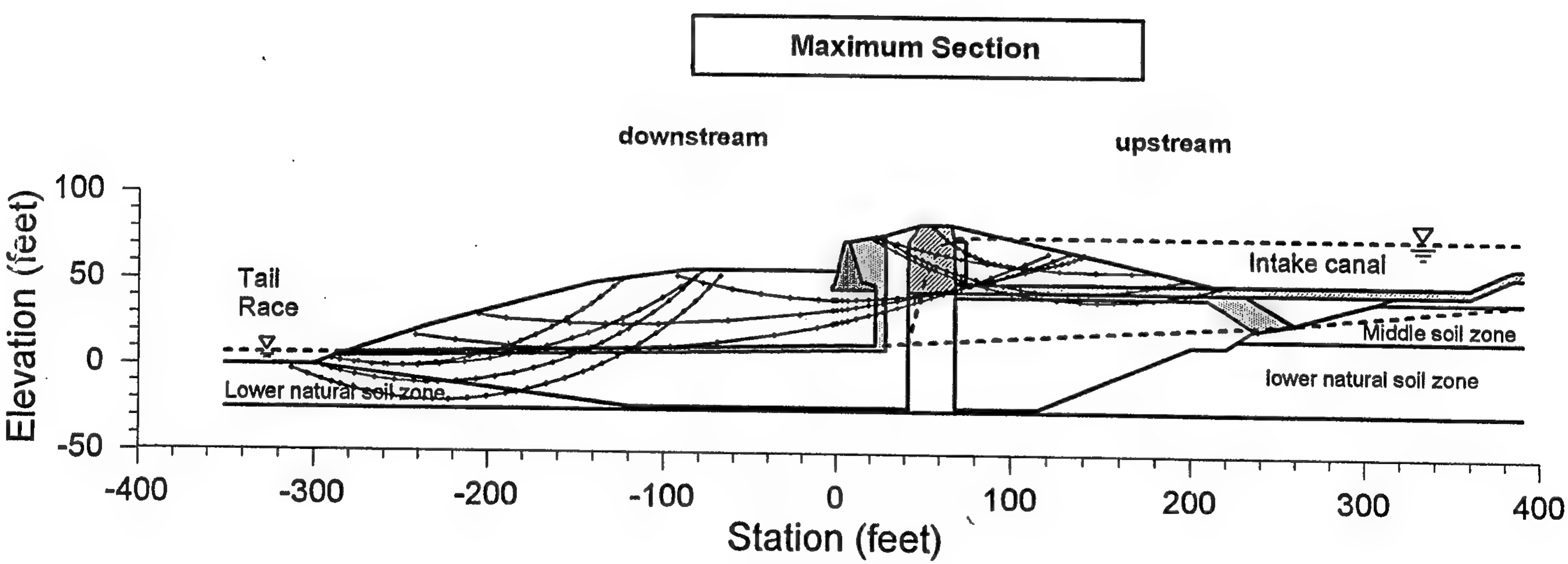


Figure 49. Yield acceleration slip surfaces, Section 3

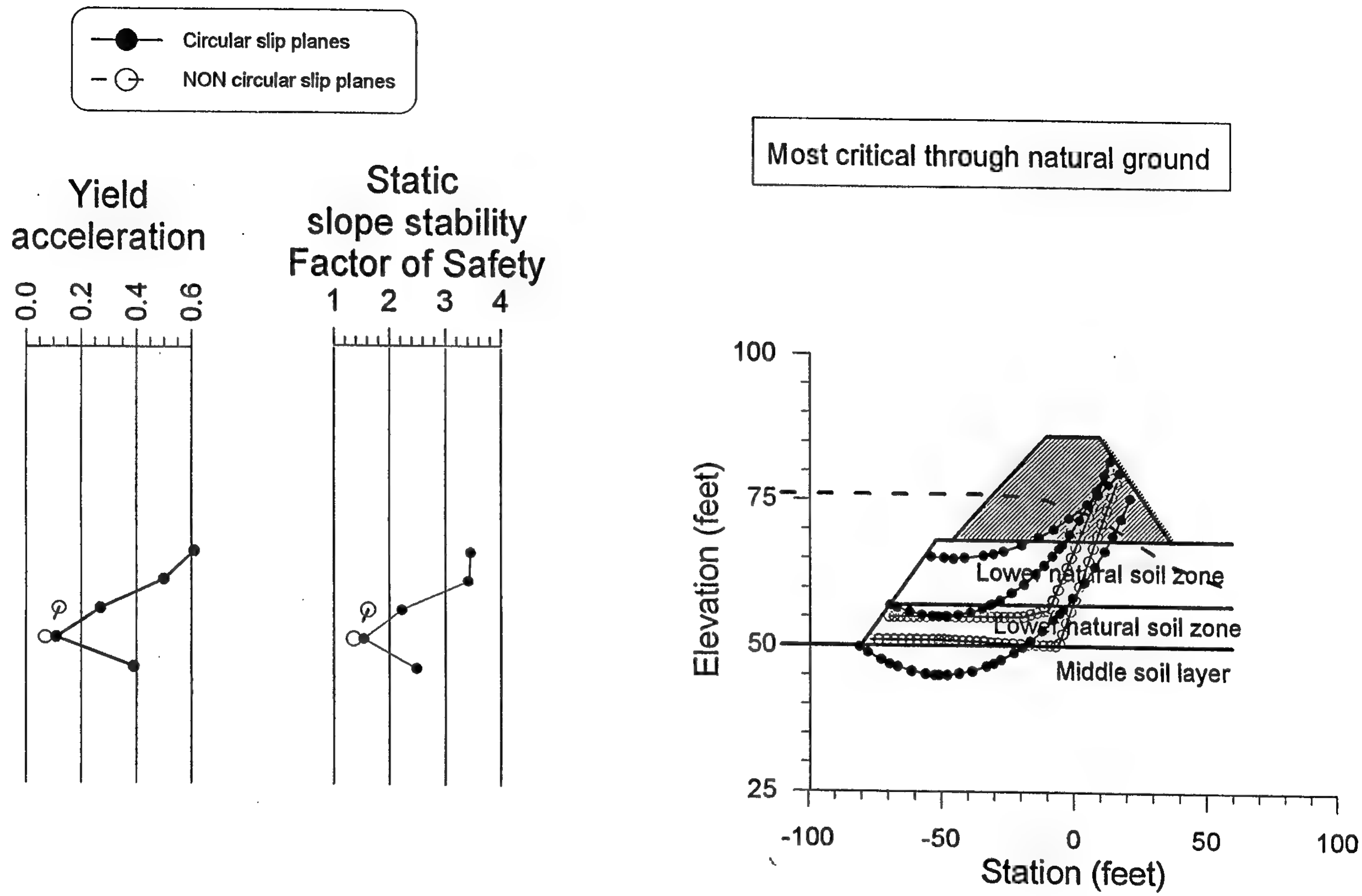


Figure 50. Section 1 yield accelerations, static factors of safety against sliding

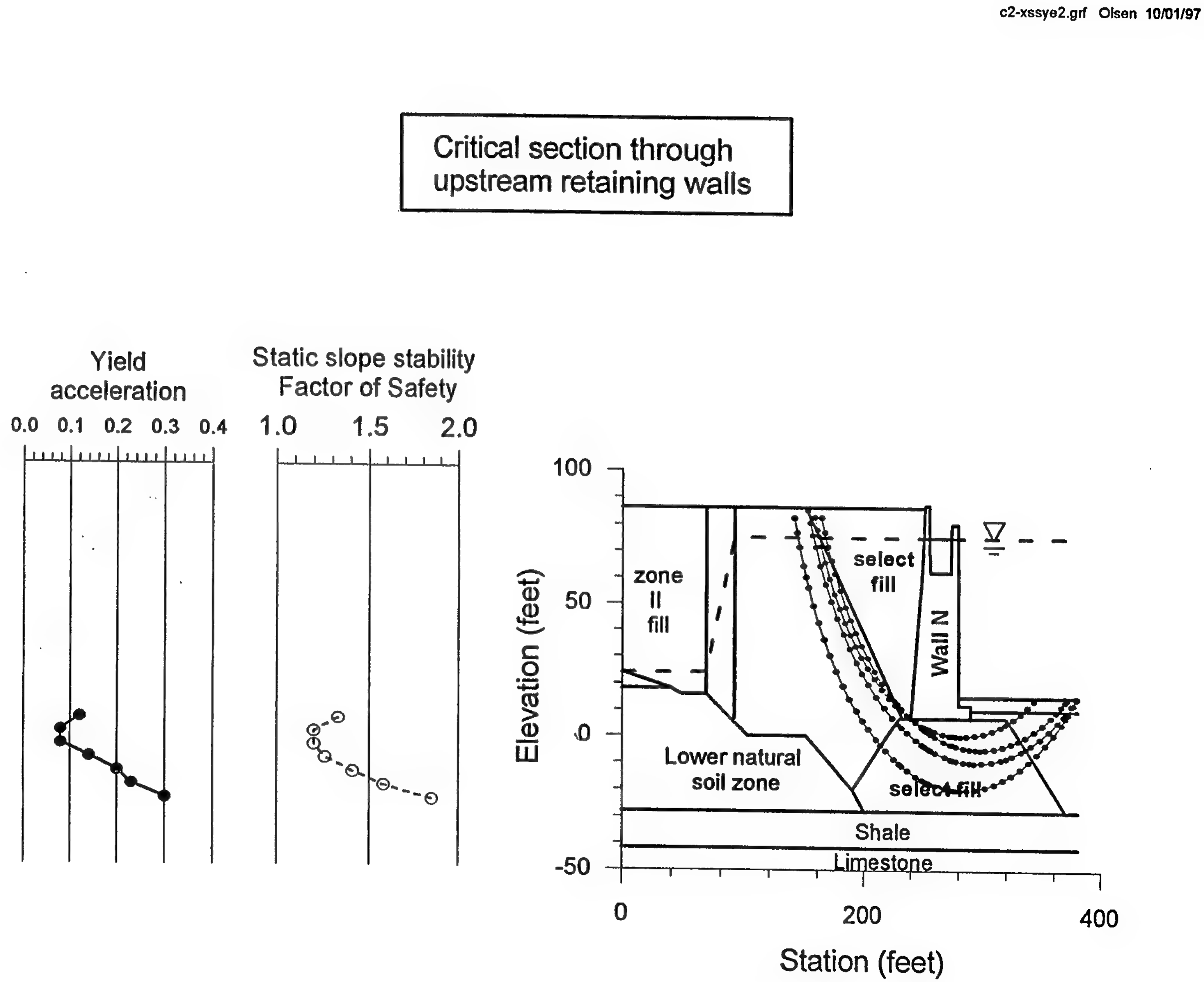


Figure 51. Section 2 yield accelerations, static factors of safety against sliding

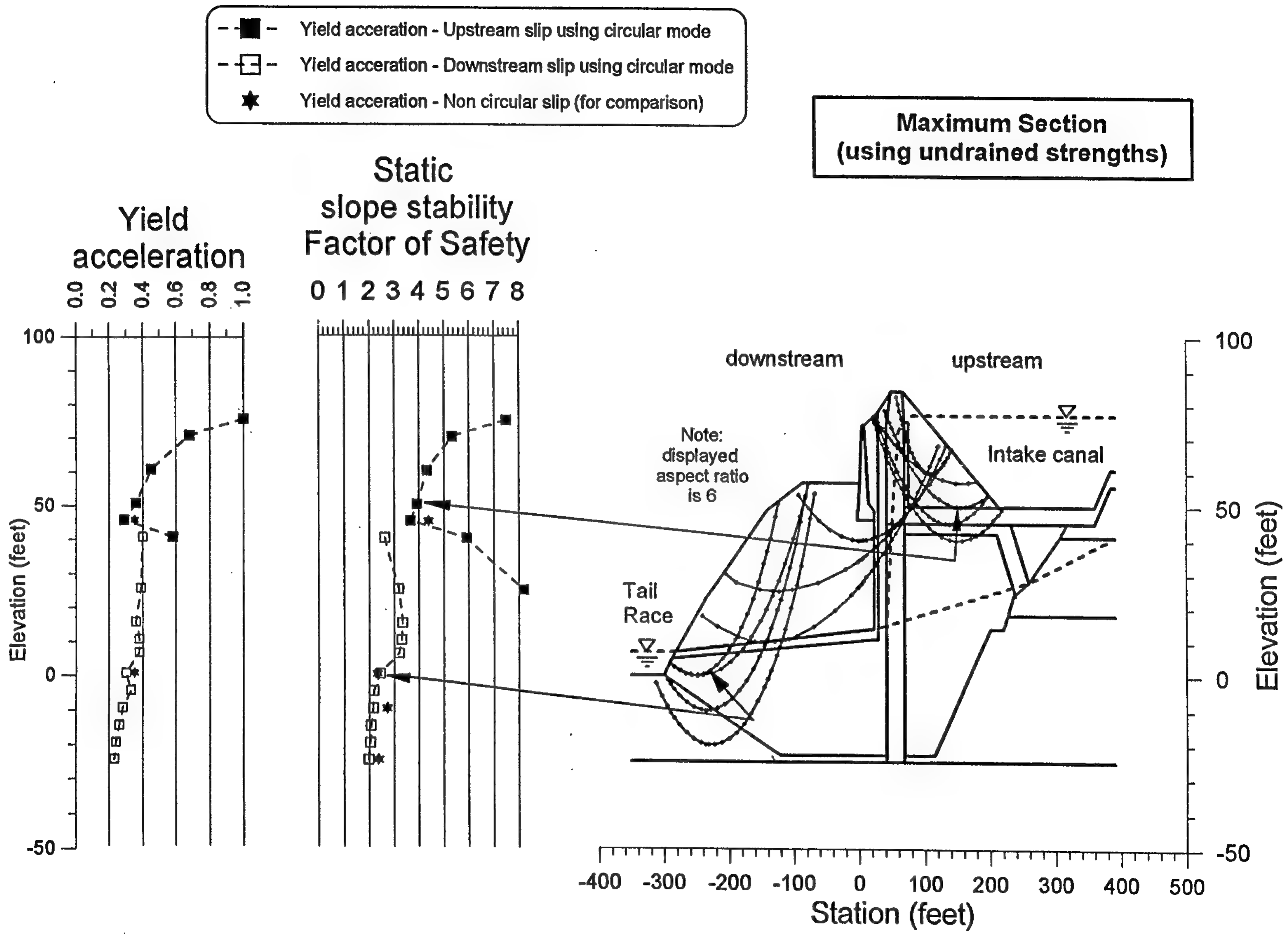


Figure 52. Section 3 yield accelerations, static factors of safety against sliding

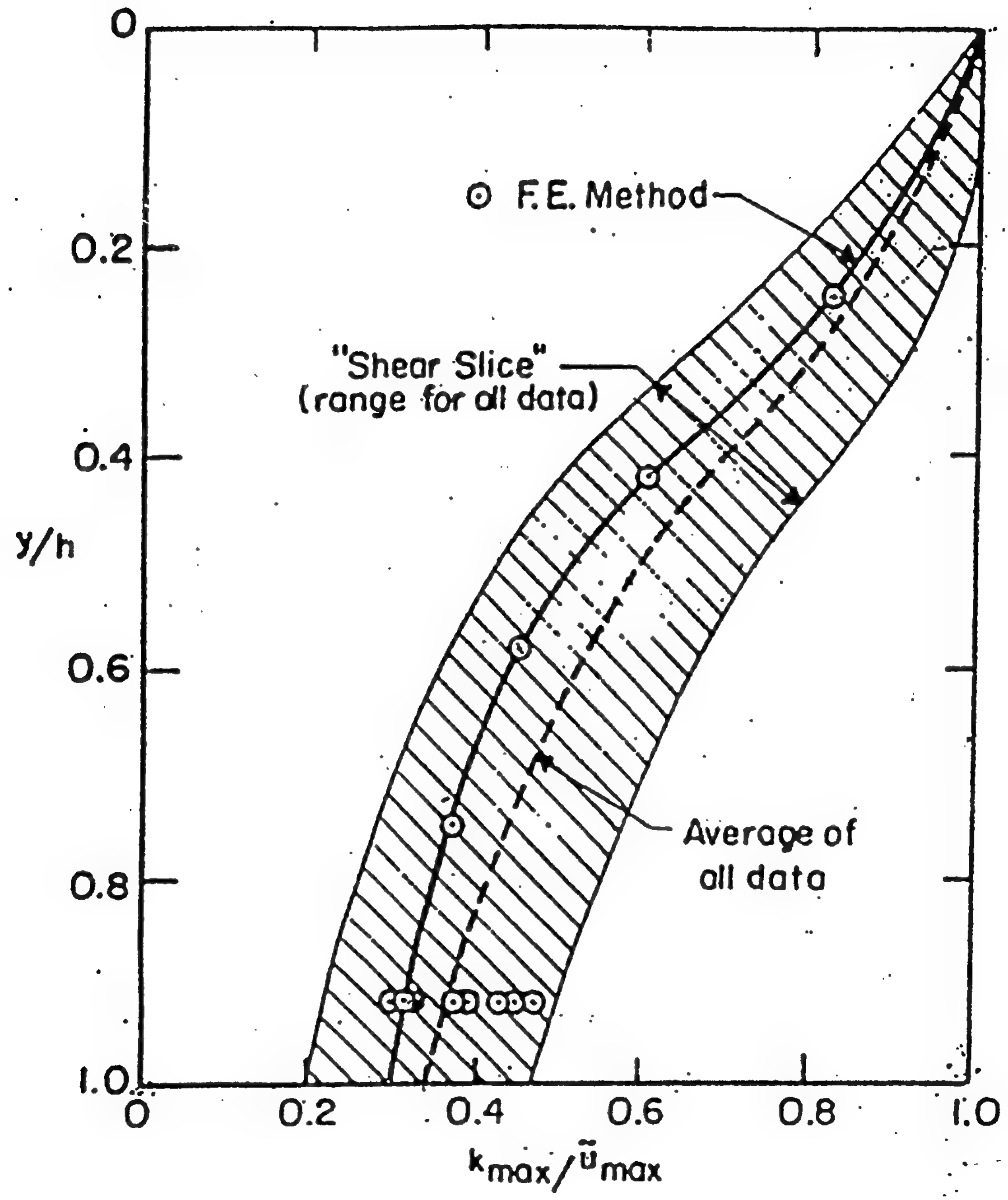


Figure 53. Makdisi-Seed dynamic response chart for Newmark-type deformation analysis (after Makdisi and Seed 1977)

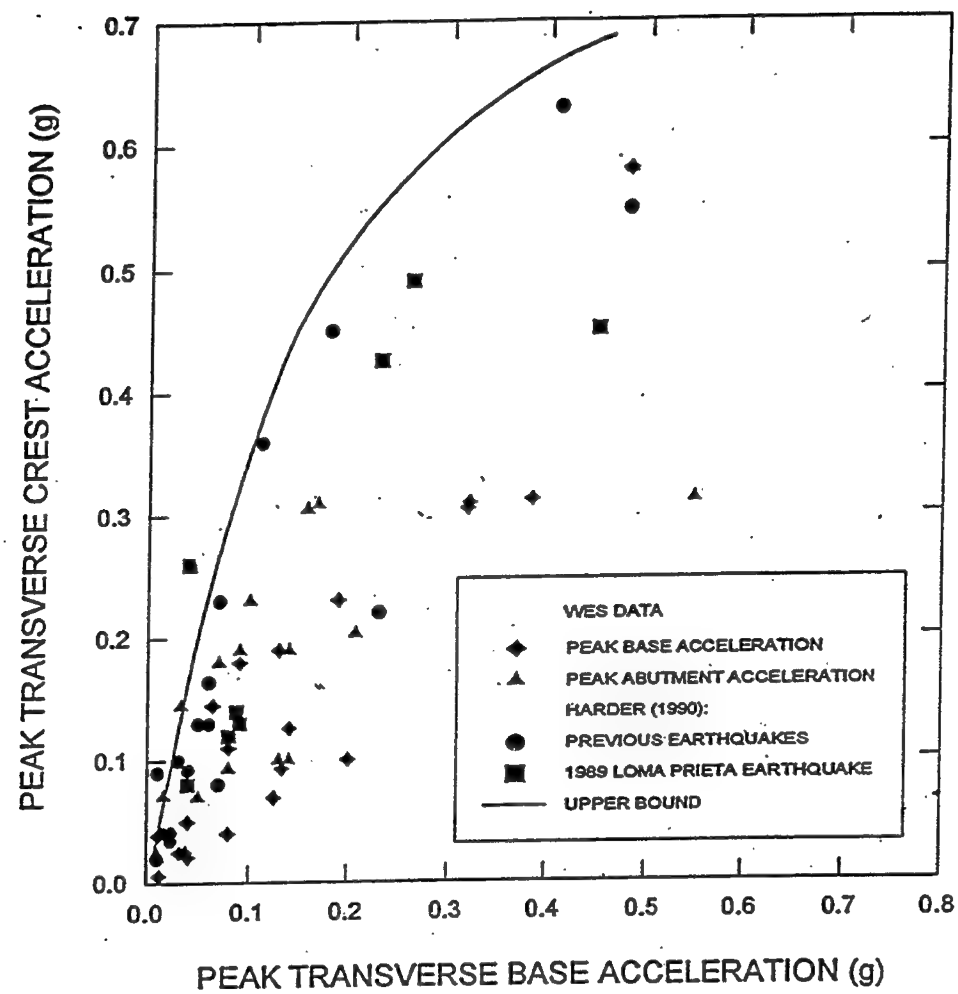


Figure 54. Upper-bound relationship between crest and base or abutment response for dams (after Harder 1991, as modified by WES 1996)

c3-xs-vs.grf Olsen 10/01/97

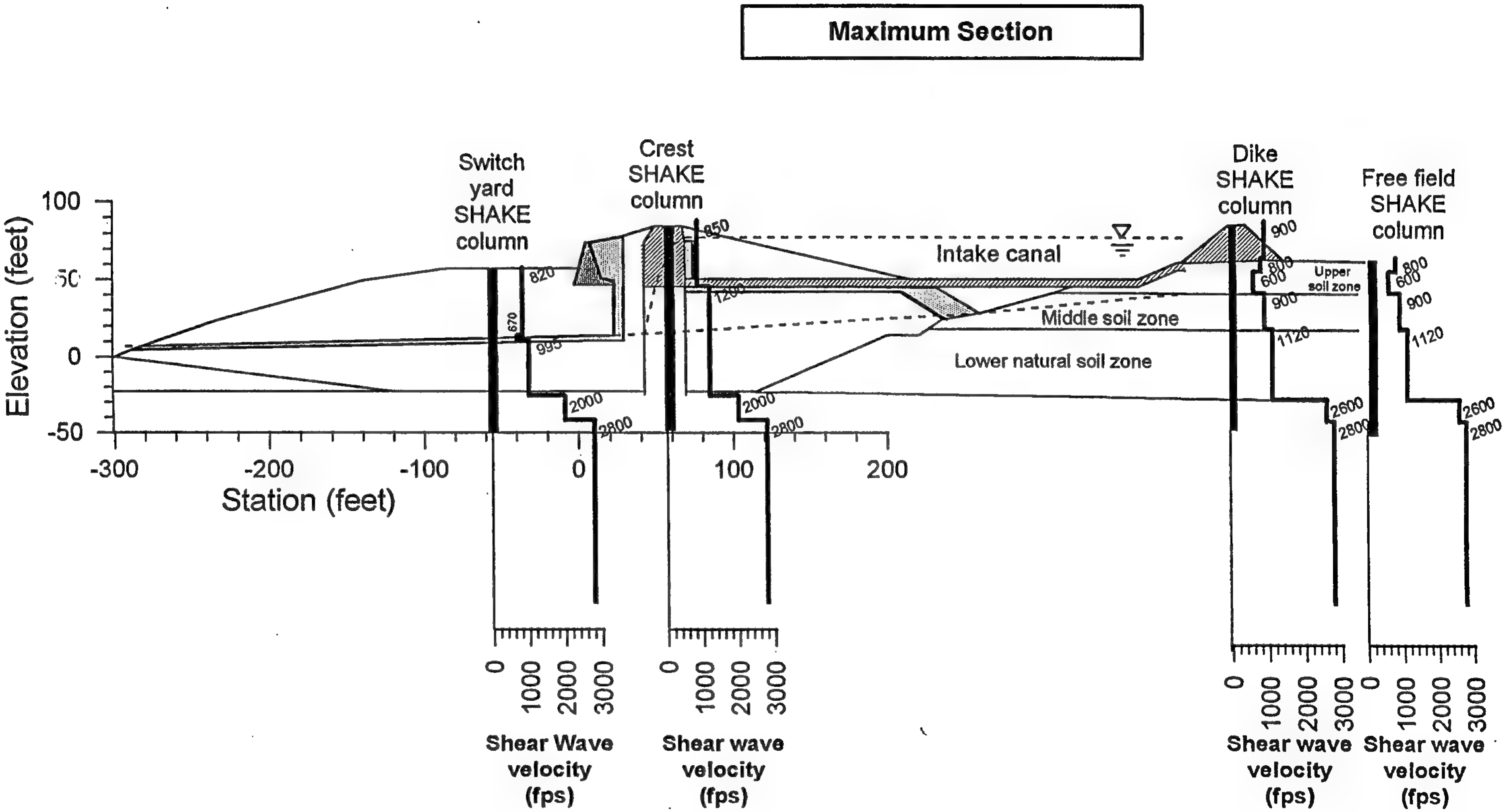


Figure 55. Locations of SHAKE profiles

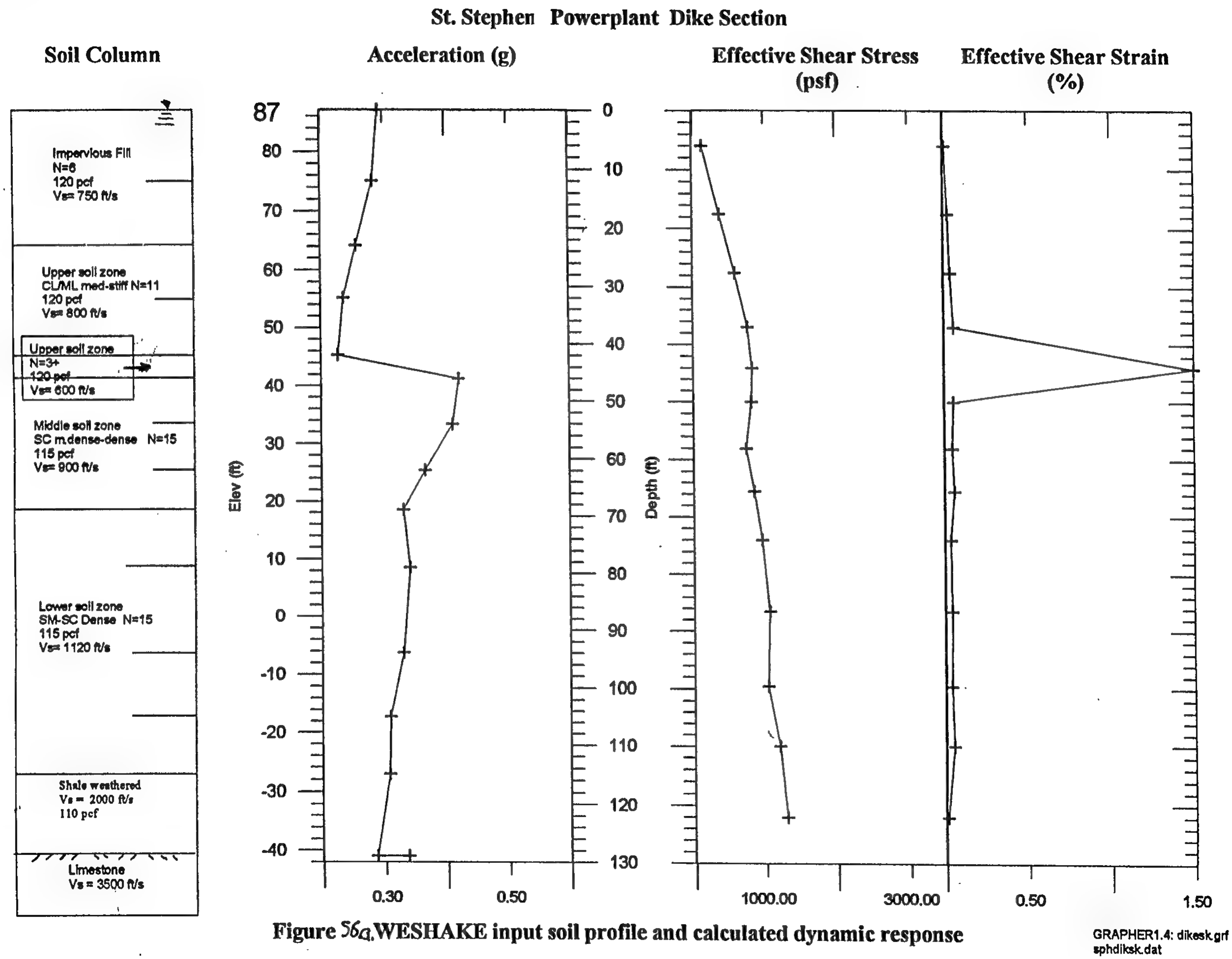


Figure 56a. WESHAKE input soil profile and calculated dynamic response

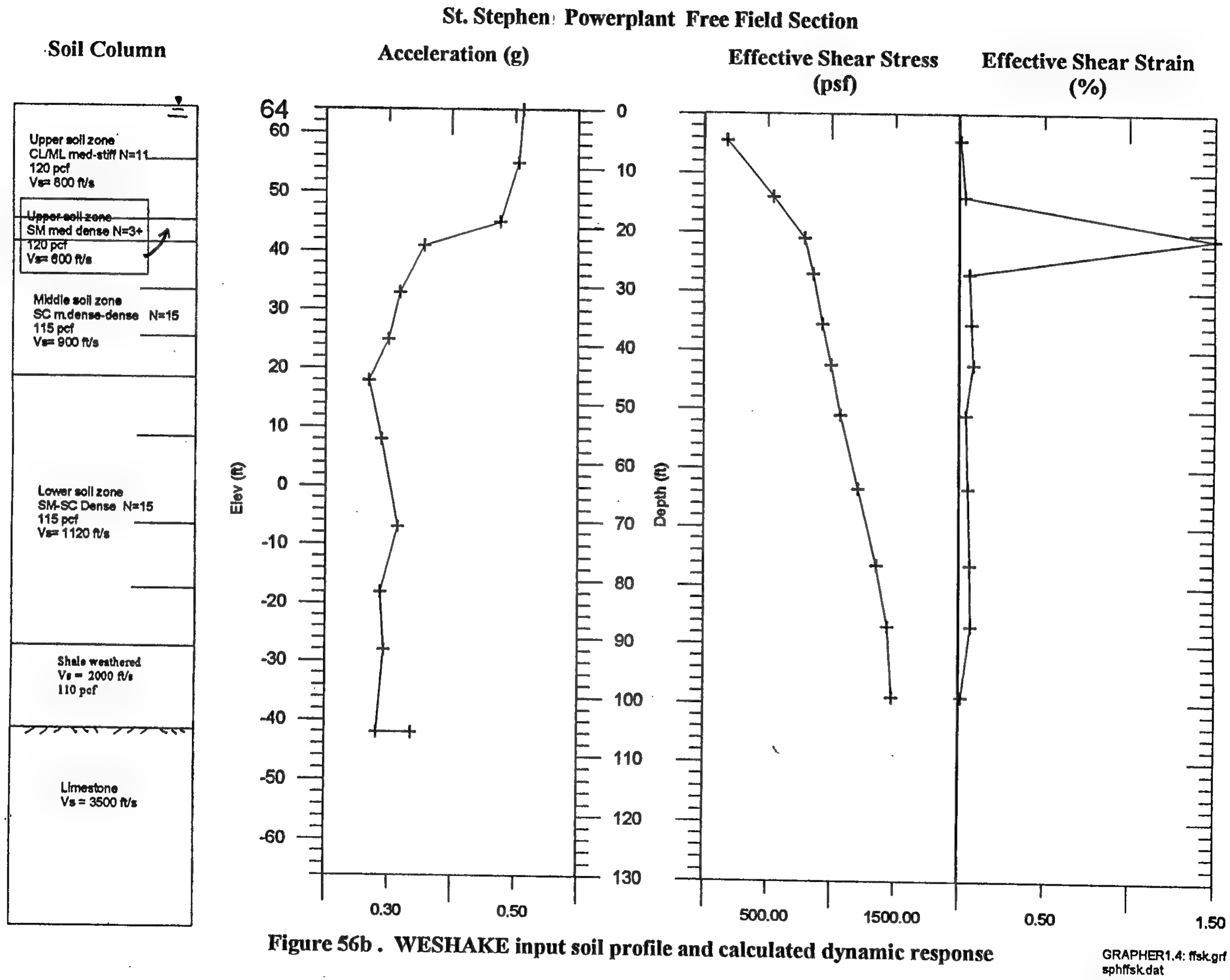


Figure 56b . WESHAKE input soil profile and calculated dynamic response

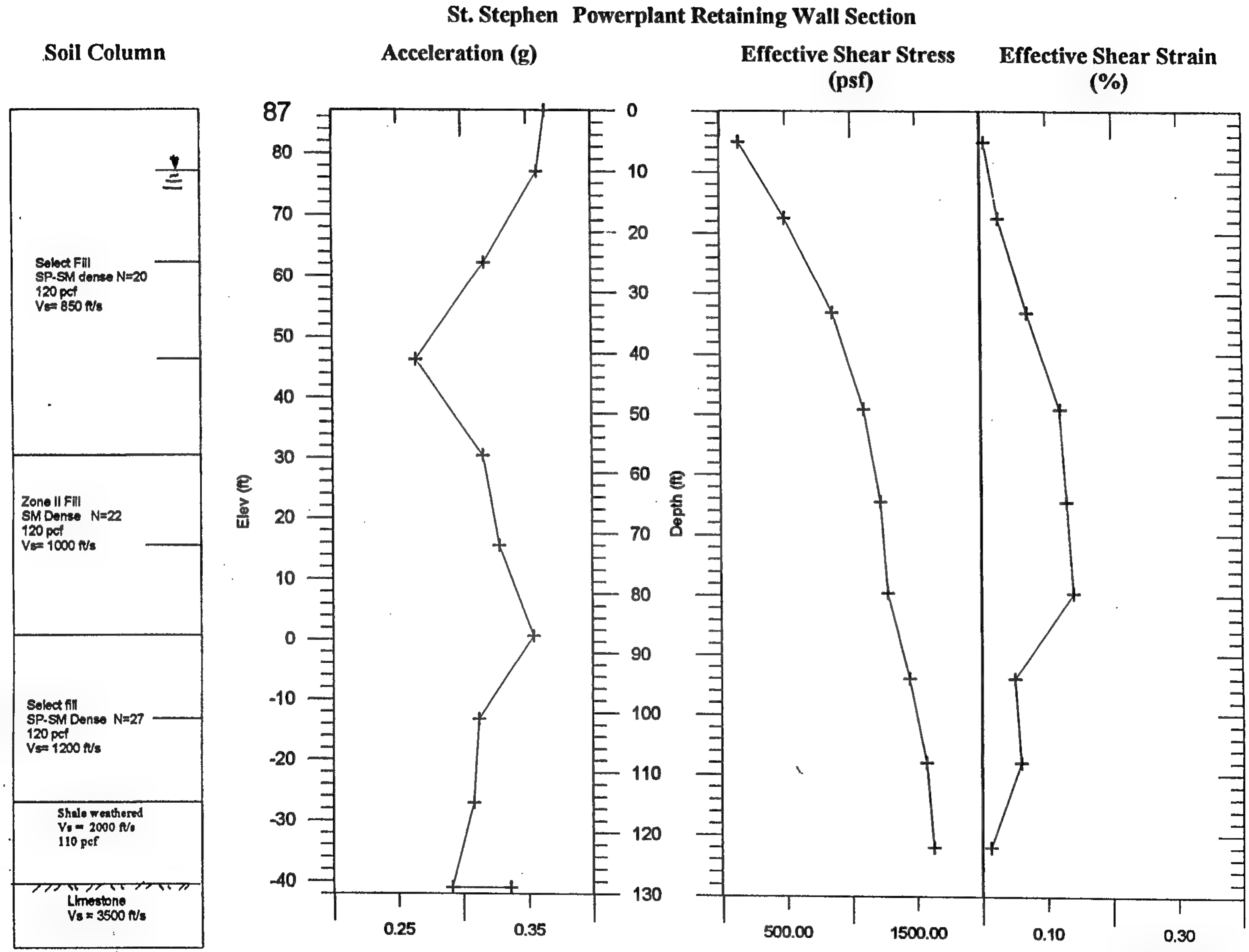


Figure 57. WESHAKE input soil profile and calculated dynamic response

GRAPHER1.4: rwalsk.grf
sphrwlsk.dat

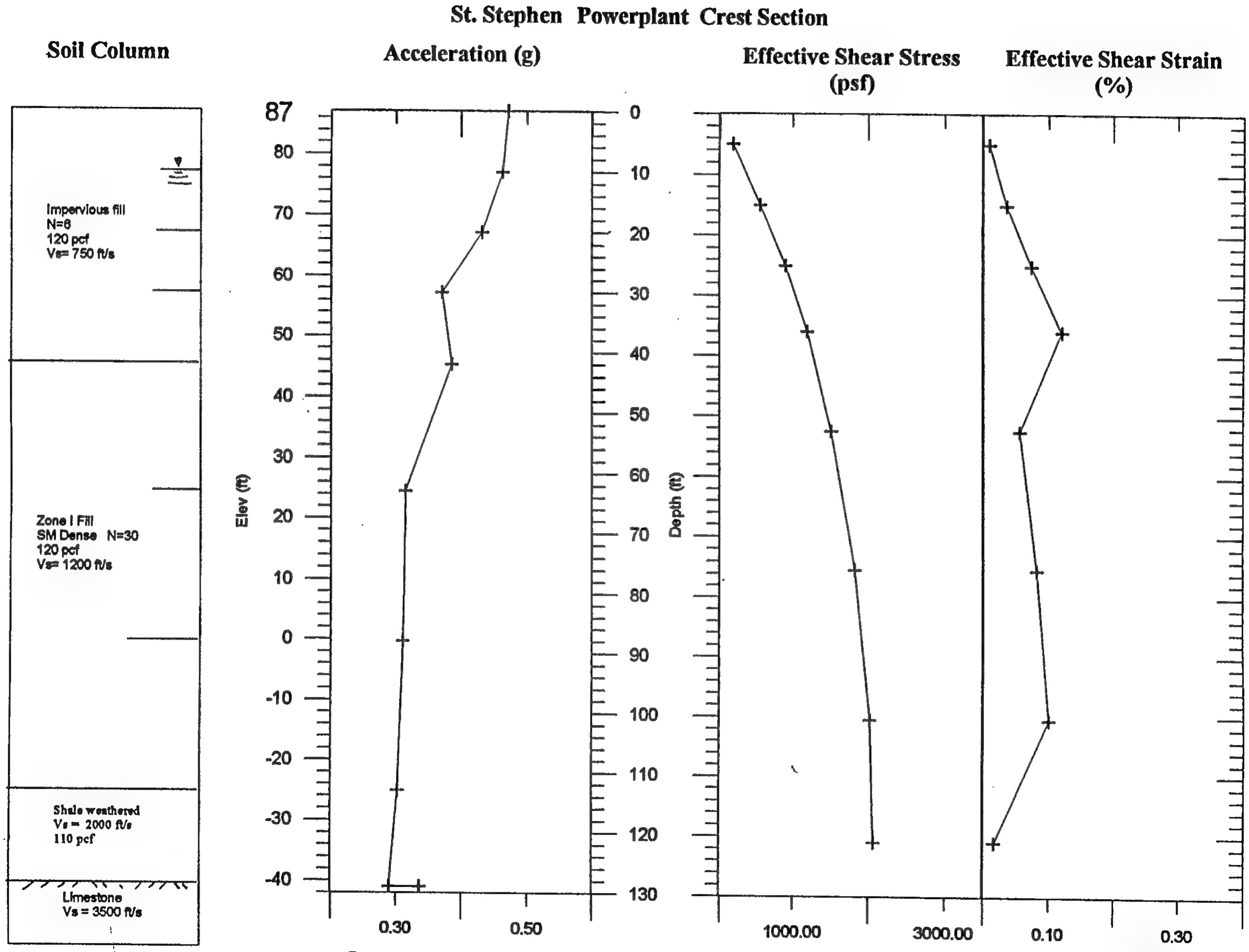


Figure 58. WESHAKE input soil profile and calculated dynamic response

GRAPHER1.4: crst4sk.grf
stvcrt4a.dat

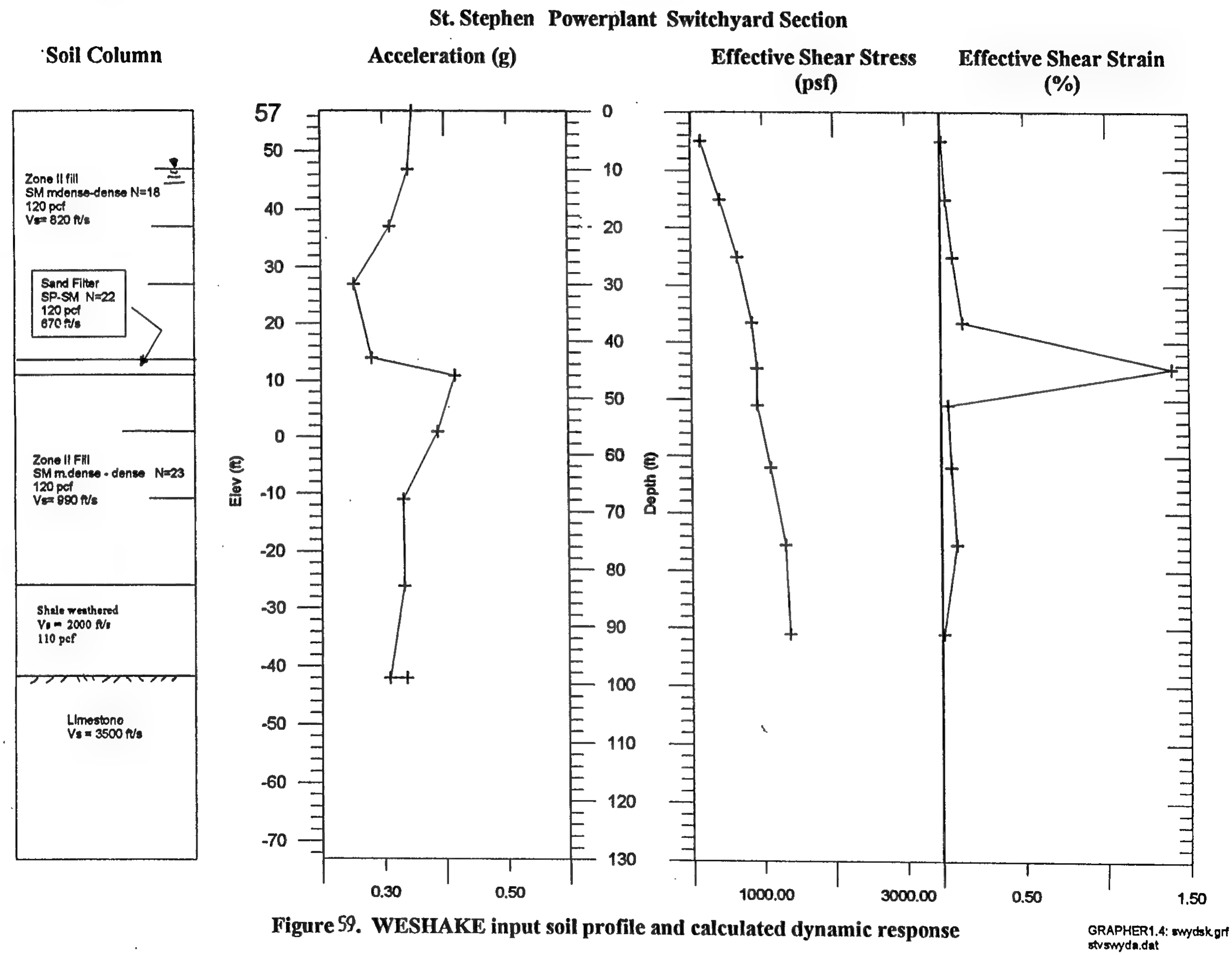


Figure 59. **WESHAKE input soil profile and calculated dynamic response**

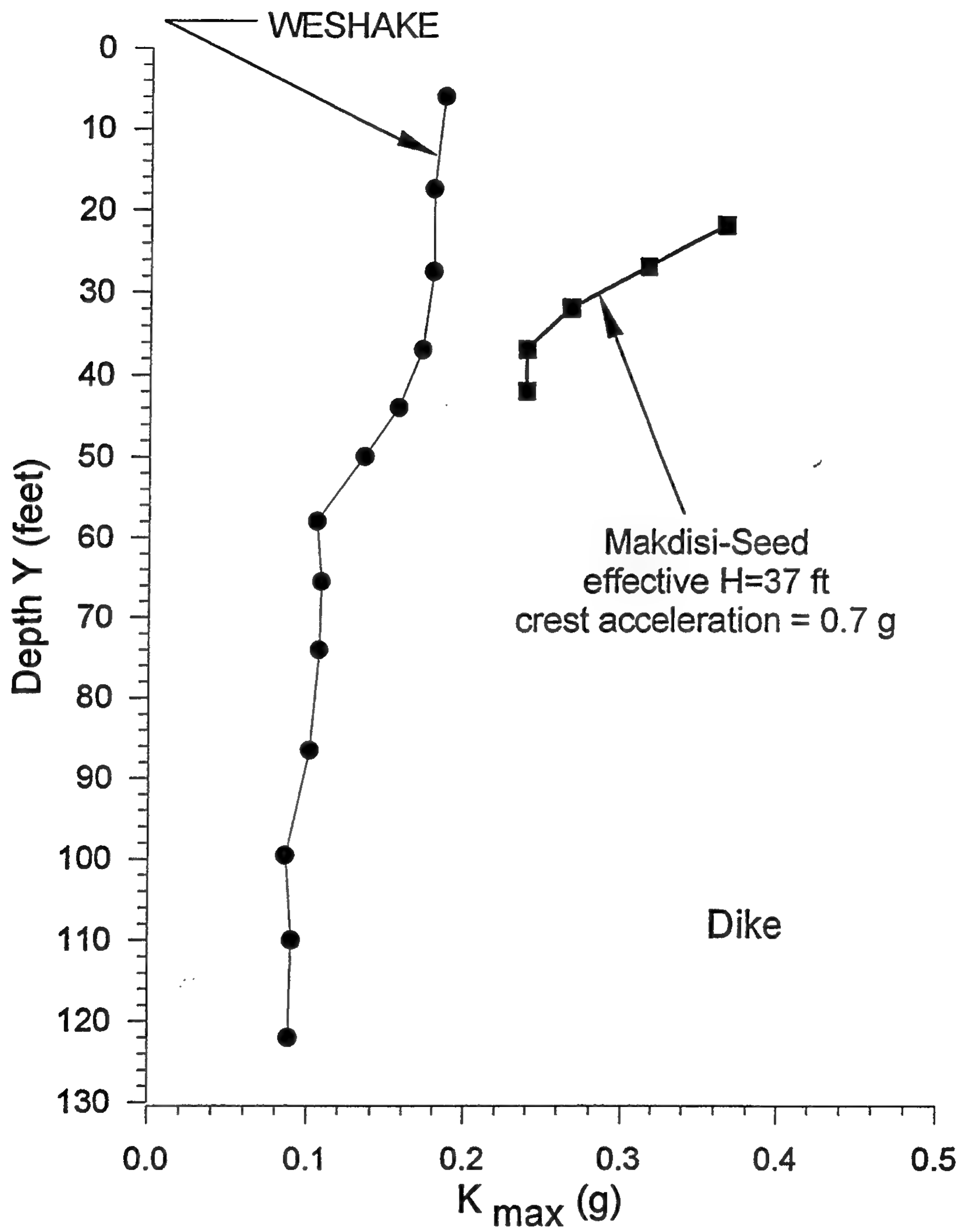


Figure 60. k_{max} values for Section 1

rw-kmax.grf Olsen 10/01/97

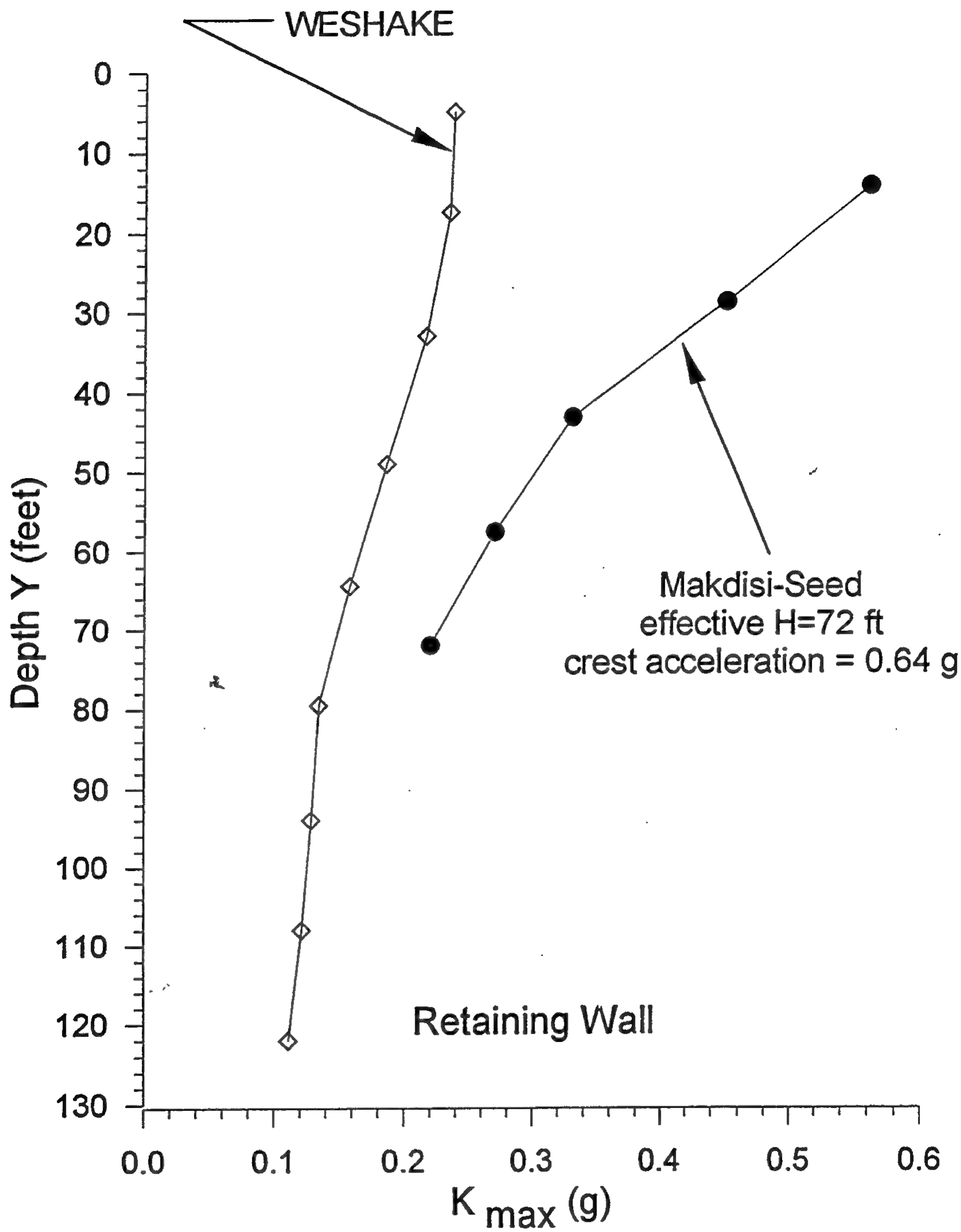


Figure 61. k_{max} values for Section 2

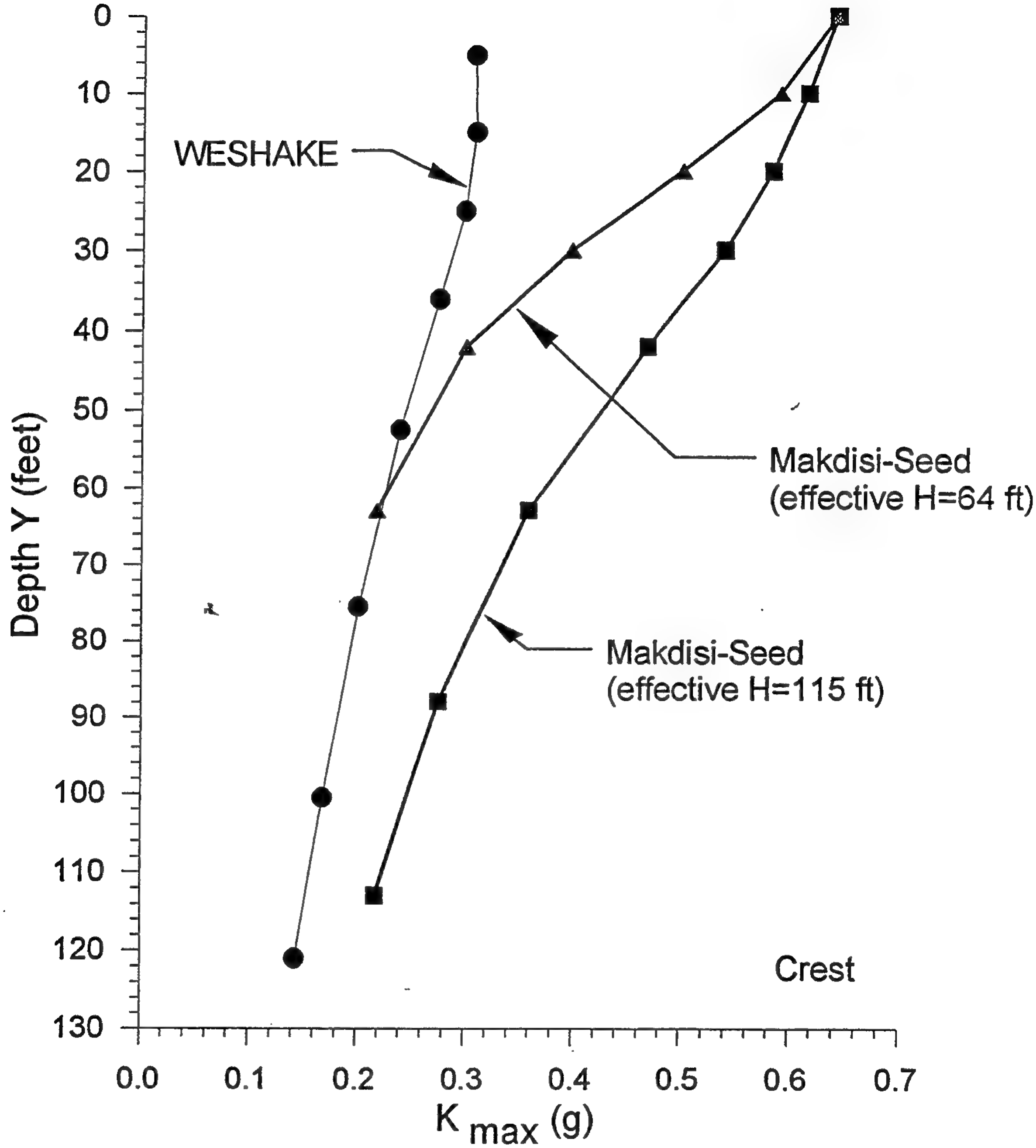


Figure 62. k_{max} values for Section 3, crest and upstream surfaces

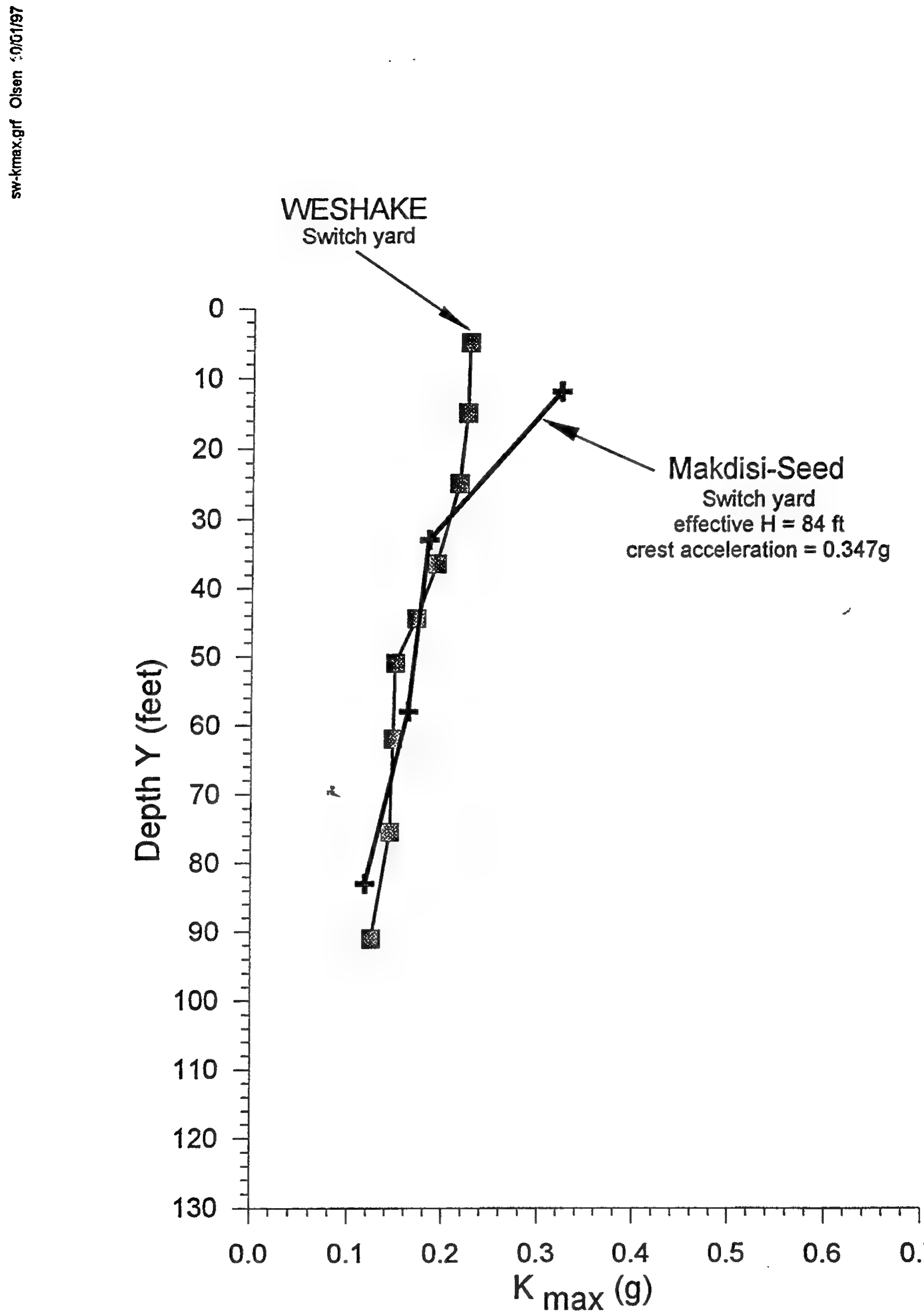


Figure 63. k_{max} values for Section 3, switchyard and downstream surfaces

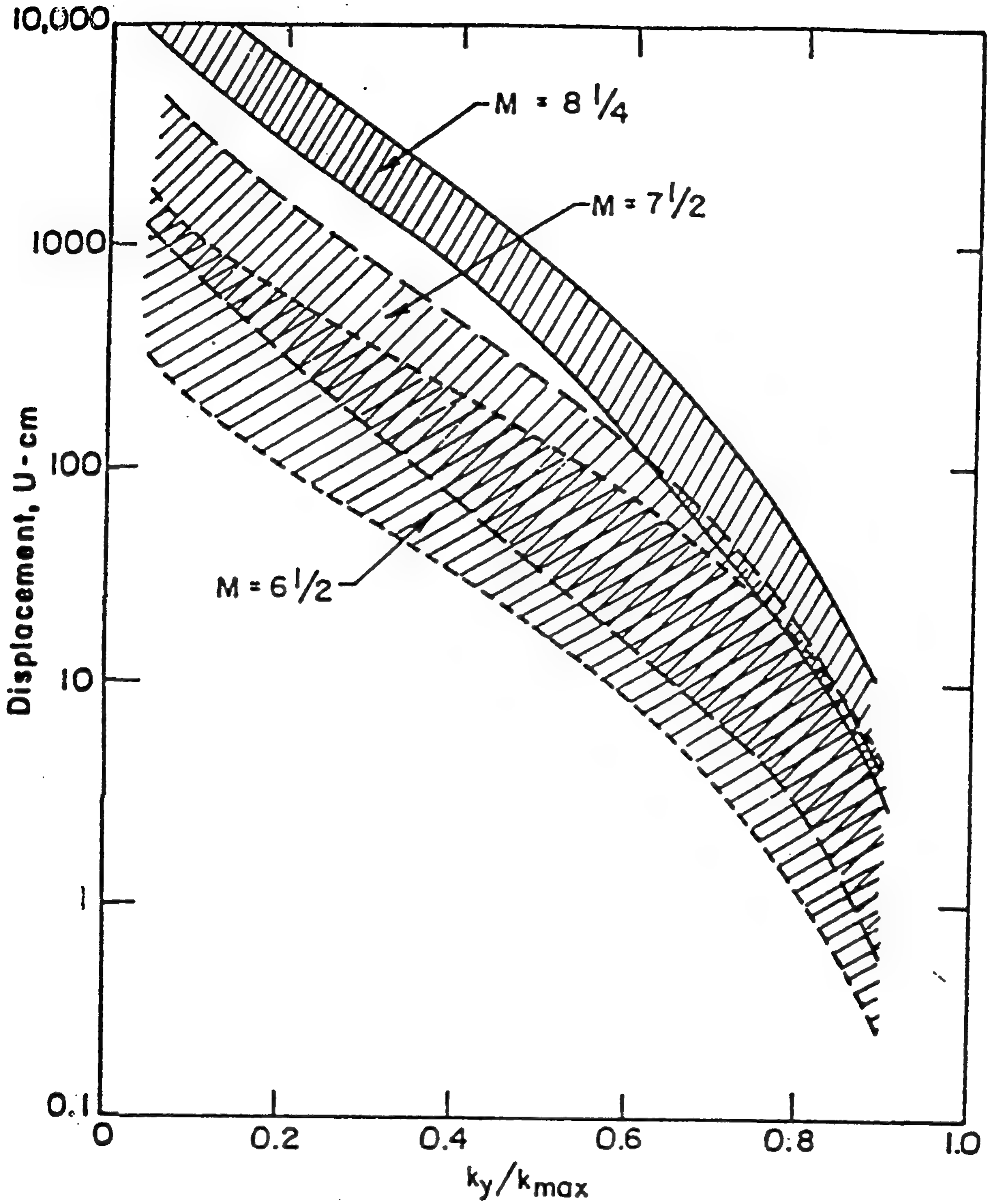


Figure 64. Makdisi-Seed displacement chart (after Makdisi and Seed 1977).

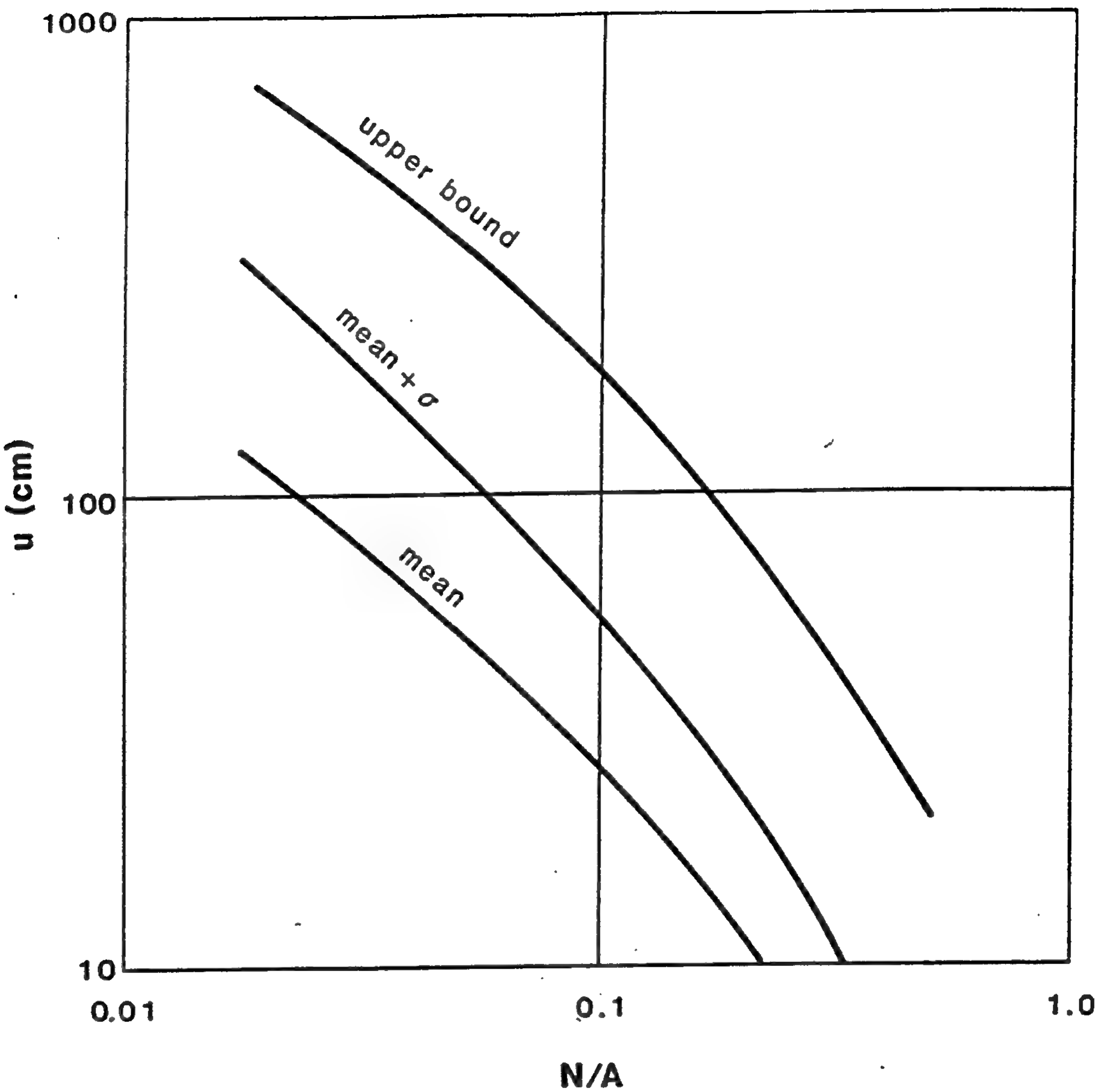


Figure 65. Hynes-Franklin displacement chart (Note: N = k_{yield} , A = k_{max} , after Hynes-Griffin and Franklin 1984)

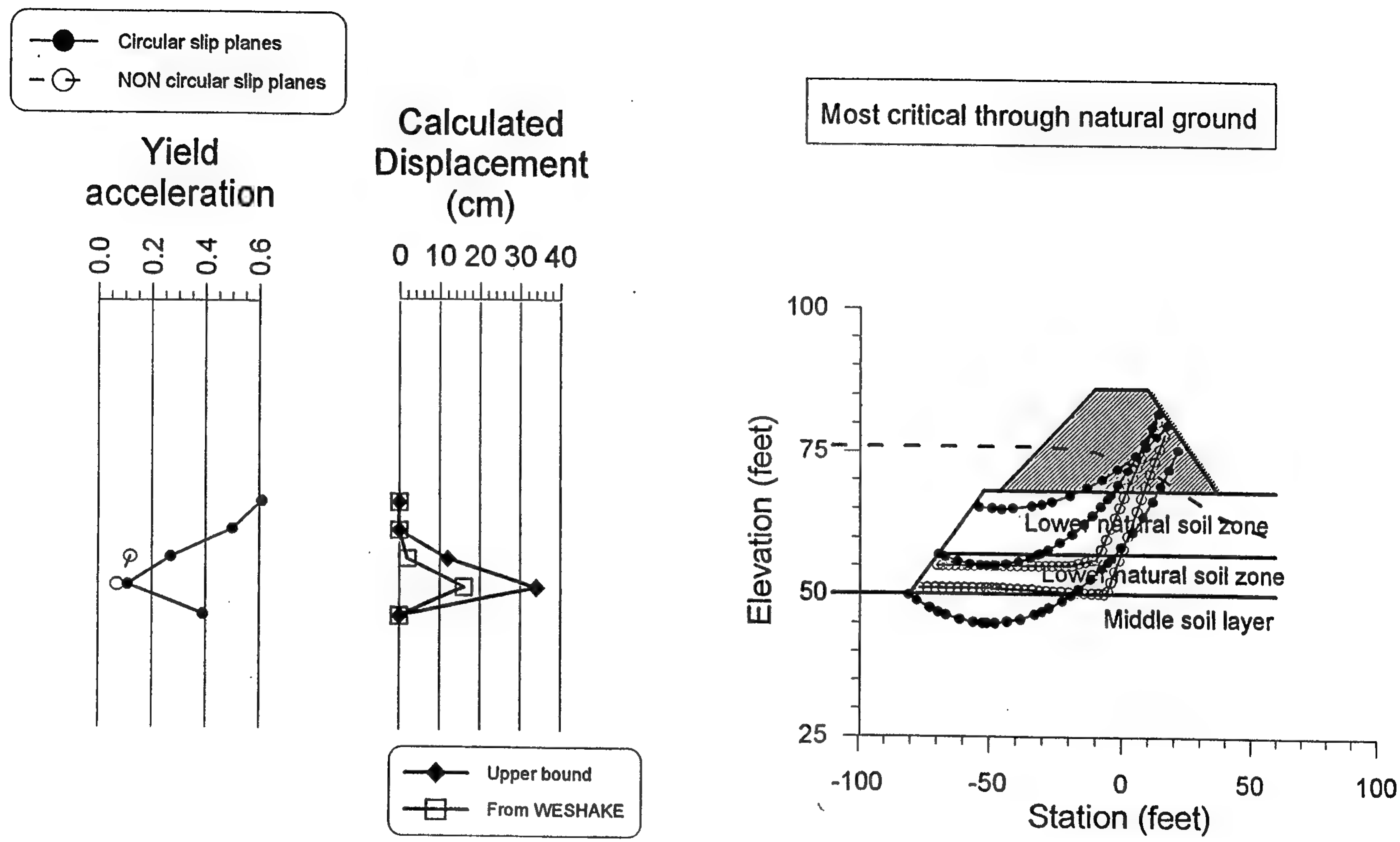


Figure 66. Displacements computed for Section 1

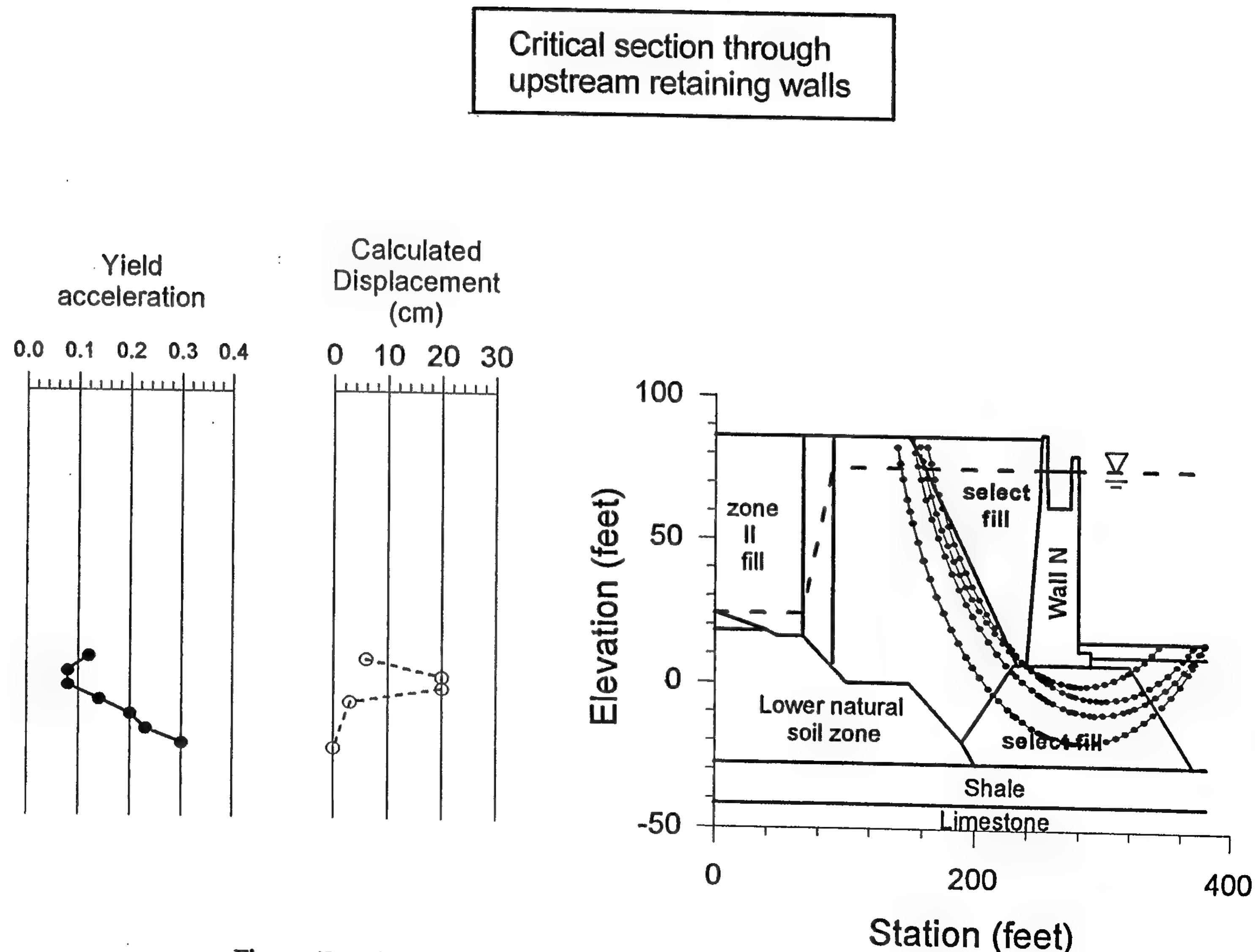


Figure 67. Displacements computed for Section 2

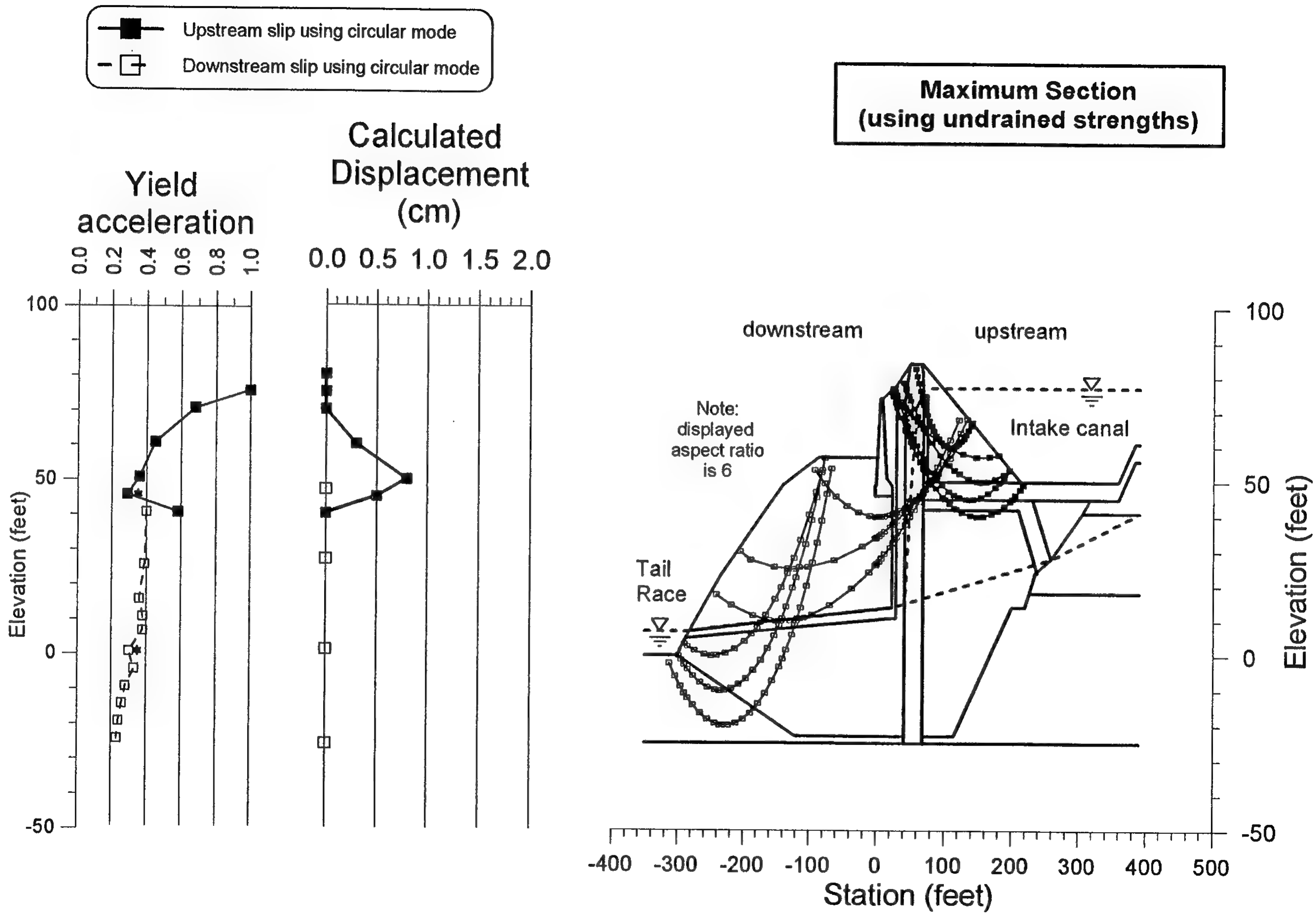


Figure 68. Displacements computed for Section 3.

APPENDIX A: SEISMIC HISTORY, $M \geq 3.5$, WITHIN 150 KM OF THE ST. STEPHEN POWERHOUSE SITE. FROM THE NATIONAL GEOPHYSICAL DATA CENTER/NOAA, BOULDER, CO

SEISMICITY (M>=3.5) WITHIN 150 KM OF 33N25' 79W56'

Wed Aug 13 17:54:01 1997

Radial Search

NGDC EARTHQUAKE DATA FILE

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
2**ISC	1974	11	22	05	25	55.6	33.082N	80.120W	18	4.20							511		31	41
2**STO	1960	03	12	12	47	44. G	33.07 N	80.12 W	9				4. LG DEW		V		511		B	42
3**DNA	1960	03	12	12	47	44.04	33.070N	80.120W	9				4.00 MG DG				511		0	42
4**BLA	1960	03	12	12	47	44.0V	33.072N	80.121W	9	4.00			3.60 CL BLA		V		511	F		42
ISC	1972	02	03	23	11	07.6	33.566N	80.362W	5	4.50							511		30	43
BLA	1992	08	21	16	31	55.0	33.050N	80.120W	10				4.40 ML BLA				511		0	44
1**PDE	1992	08	21	16	31	55.1	33.050N	80.116W	10G	4.1		4.40 TUL	4.10 LG GS		V		511	F	16	44
1**USN	1972	02	03	23	11	08.4	33.5 N	80.4 W	5	4.5					V		511		A	44
2**BLA	1992	08	21	16	31	55.2V	33.050N	80.116W	10	4.10			4.40 MD NES		V		511		16	44
3**STO	1959	08	03	06	08	36.8G	33.05 N	80.13 W	1				4.4 LG DEW		VI		511		B	44
4**DNA	1959	08	03	06	08	36.84	33.050N	80.130W	1				4.40 MG DG				511		0	44
5**BLA	1959	08	03	06	08	36.8V	33.054N	80.126W	1	4.40			4.40 CL BLA		VI		511	F		44
BLA	1977	01	18	18	29	14.1V	33.058N	80.173W	1			3.00 BLA	3.80 NU BLA		VI		511			45
BLA	1994	06	20	05	52	38.5V	33.040N	80.162W	2	1.10			2.70 DR BLA		III		511			46
STO	1978	09	07	22	53	23. G	33.063N	80.21 W	10				2.7 LG GS		IV		511		A	46
1**BLA	1978	09	07	22	53	23.0V	33.063N	80.210W	10				2.60 MD SLM		IV		511		28	46
2**BLA	1978	09	07	22	53	23.0V	33.063N	80.210W	10	3.30		2.60 BLA	2.70 NU BLA		IV		511			46
2**PDE	1972	02	03	23	11	08.4*	33.476N	80.434W	5G	4.5					V		511	F	16	46
1**STO	1977	01	18	18	29	14.2G	33.04 N	80.21 W	7				3. LG BLA		VI		511		A	49
BLA	1979	12	07	05	43	34.9V	33.008N	80.163W	5				2.80 MD SLM		IV		511		24	50
1**STO	1979	12	07	05	43	34.9G	33.008N	80.163W	5				2.8 LG GS		IV		511		A	50
2**BLA	1979	12	07	05	43	34.9V	33.008N	80.163W	5	3.30		2.80 BLA	2.80 NU BLA		IV		511			50
USN	1908	03	03	21	06		33. N	80.2 W							III		511		G	52
USN	1908	03	07	06	50		33. N	80.2 W							III		511		G	52
USN	1908	10	28	11	24		33. N	80.2 W							III		511		G	52
1**EQH	1914	09	22	07	04	Z	33. N	80.2 W							V		511	F		52
1**USN	1908	01	15	19			33. N	80.2 W							III		511		G	52
1**USN	1933	07	26	02	34		33. N	80.2 W							III		511		G	52
1**USN	1933	12	19	14	12		33. N	80.2 W							IV		511		G	52
1**USN	1961	05	20	15	43		33. N	80.2 W							III		511		G	52
2**EQH	1912	06	12	10	30	Z	33. N	80.2 W							VII		511	D		52
3**BLA	1992	08	21	16	31	56.1V	32.985N	80.163W	7				4.09 MD MRO		VI		511		13	52
4**BLA	1992	08	21	16	31	56.1V	32.986N	80.164W	7				4.09 MD MRO		VI		511		0	52
5**BLA	1992	08	21	16	31	56.1V	32.985N	80.163W	6	3.80		4.09 BLA	4.09 NU BLA		VI		511			52
PDE	1995	04	17	13	45	57.8	32.947N	80.068W	10G				3.90 LG GS		VI		511	D	7	53
STO	1975	04	28	05	46	52.6G	33. N	80.22 W	10				3. LG SLM		IV		511		A	53
1**BLA	1975	04	28	05	46	52.6V	33.000N	80.220W	10			3.00 BLA	3.30 NU BLA		IV		511			53
BLA	1979	08	11	02	11	56.6V	32.992N	80.223W	10				2.50 MD SLM		III		511		14	54
BLA	1980	09	01	05	44	42.2V	32.978N	80.186W	7				2.90 MD SLM		IV		511		19	54
BLA	1993	06	15	13	19	02.9V	32.977N	80.186W	6	1.90			2.70 DR BLA		III		511			54
ISC	1990	05	11	18	23	33.7	32.956N	80.146W	11	3.50							511		15	54
PDE	1986	03	09	23	49	15.3S	32.968N	80.169W	6				2.20 MD GLD		III		511	F	9	54
TEI	1990	11	13	15	22	09.0I	32.934N	80.021W	9				3.50 ML TEI				511		1	54
1**BLA	1980	09	01	05	44	42.2V	32.978N	80.186W	7	3.30		2.90 BLA	2.70 NU BLA		IV		511			54

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
1**BLA	1986	03	09	23	49	15.4V	32.968N	80.169W	6				2.20 MD SLM		III		511		16	54
1**STO	1979	08	11	02	11	56.6G	32.992N	80.223W	10				2.5 LG GS		III		511		A	54
2**BLA	1979	08	11	02	11	56.6V	32.992N	80.223W	10	2.70		2.50 BLA	2.50 NU BLA		III		511			54
2**BLA	1986	03	09	23	49	15.4V	32.968N	80.169W	5	2.20			2.70 DR BLA		III		511			54
2**STO	1980	09	01	05	44	42.3G	32.978N	80.186W	6				2.7 LG GS		IV		511		A	54
3**BLA	1963	05	04	21	01	50.3V	32.972N	80.193W	5	3.30			3.30 MB BLA		IV		511			54
BLA	1981	03	19	04	33	55.4V	32.960N	80.188W	6				2.29 MD SLM		III		511		16	55
BLA	1990	02	18	12	09	39.8V	32.961N	80.175W	2				2.10 MD SLM		III		511		16	55
BLA	1990	06	18	10	03	33.4V	32.951N	80.158W	5				2.60 MD SLM		III		511		33	55
BLA	1991	02	18	20	45	10.7V	32.962N	80.179W	4	1.40			2.70 DR BLA		III		511			55
BLA	1991	06	02	06	05	34.9V	32.980N	80.214W	5	1.70			3.50 DR BLA		V		511			55
1**BLA	1981	03	19	04	33	55.4V	32.960N	80.188W	5	2.70		2.29 BLA	2.50 NU BLA		III		511			55
1**BLA	1990	02	18	12	09	39.8V	32.961N	80.175W	1	2.10			2.70 DR BLA		III		511			55
1**BLA	1990	05	11	18	23	34.0V	32.951N	80.155W	6				2.60 MD SLM		III		511		27	55
1**BLA	1990	06	18	10	03	33.4V	32.951N	80.158W	4	2.60			2.70 DR BLA		III		511			55
1**PDE	1990	11	13	15	22	13.0S	32.947N	80.136W	3				3.20 MD GLD		V		511	F	31	55
2**BLA	1990	05	11	18	23	34.0V	32.951N	80.155W	6	2.60			2.70 DR BLA		III		511			55
2**BLA	1990	11	13	15	22	13.0V	32.947N	80.136W	3	3.50			3.20 MD SLM		V		511		22	55
2**STO	1963	05	04	21	01	50.3G	32.97 N	80.19 W	5				3.3 SL JLM		IV		511		B	55
2**STO	1981	03	19	04	33	55.7G	32.96 N	80.188W	6				2.5 LG GS		III		511		A	55
3**BLA	1990	11	13	15	22	13.0V	32.947N	80.136W	3	3.50		3.20 BLA	3.50 NU BLA		V		511			55
BLA	1990	01	07	16	13	16.7V	32.968N	80.218W	5				2.10 MD SLM		III		511		22	56
STO	1977	03	30	08	27	47.8G	32.95 N	80.18 W	8				2.9 CL TAR		V		511		A	56
STO	1982	03	01	03	33	13.0	32.940N	80.140W	7				3.00 ML STO		IV		511			56
1**BLA	1977	03	30	08	27	47.8V	32.950N	80.180W	8	2.90			3.50 DR BLA		V		511			56
1**BLA	1977	12	15	19	16	43.6V	32.944N	80.167W	8				2.60 MD SLM		V		511		17	56
1**BLA	1982	03	01	03	33	13.6V	32.936N	80.138W	7				2.80 MD SLM		IV		511		8	56
1**BLA	1990	01	07	16	13	16.7V	32.968N	80.218W	5	2.10			2.70 DR BLA		III		511			56
2**PDE	1982	03	01	03	33	13.6G	32.936N	80.138W	7G				3. LG GS		IV		511	F	11	56
2**STO	1977	12	15	19	16	43.6G	32.944N	80.167W	8				3. LG BLA		V		511		A	56
3**BLA	1977	12	15	19	16	43.6V	32.944N	80.167W	7	3.50		2.60 BLA	3.00 NU BLA		V		511			56
3**BLA	1982	03	01	03	33	13.6V	32.936N	80.138W	6	3.30		2.80 BLA	3.00 NU BLA		IV		511			56
BLA	1698	03	05			V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
BLA	1754	05	19	16		V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
BLA	1799	04	11	19	55	V	32.900N	80.000W					3.50 MB BLA		V		511	F		57
BLA	1860	01	19	23		V	32.900N	80.000W					3.50 MB BLA		V		511	F		57
BLA	1860	10				V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
BLA	1886	06				V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
BLA	1886	08	27	06	30	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
BLA	1886	08	27	13	30	V	32.900N	80.000W					3.50 MB BLA		V		511	F		57
BLA	1886	08	28	06	30	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
BLA	1886	08	28	09	40	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
BLA	1886	08	28	19	57	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
BLA	1886	09	01	02	51	V	32.900N	80.000W					6.90 MB BLA				511	F		57
BLA	1886	09	01	05	55	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
BLA	1886	09	03	04	53	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57

DUP	SOURCE	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
	BLA	1886	09	04	04	01		V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
	BLA	1886	09	06	04	06		V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
	BLA	1886	09	06	16	35		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1886	09	08	17	55		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1886	09	09	06	06		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1886	09	14				V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1886	09	17	06	29		V 32.900N	80.000W					3.80 MB BLA		VI		511	F		57
	BLA	1886	09	20	05			V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1886	09	21	21	15		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1886	09	30	22	10		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1886	10	09	03	40		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1886	10	09	05	40		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1886	10	09	06	48		V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
	BLA	1886	10	09	18	46		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1886	10	15	12	40		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1886	10	22	10	20		V 32.900N	80.000W					4.40 CL BLA		VI		511			57
	BLA	1886	10	23	01	07		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1886	10	31	21	46		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1886	11	05	17	20		V 32.900N	80.000W					4.40 CL BLA		VI		511			57
	BLA	1886	11	28	15	10		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1886	11	28	20	13		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1886	12	06				V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1887	01	03	06	20		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1887	03	18	23	10		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1887	03	24	04	05		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1887	03	28				V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1887	04	14	07	25		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1887	04	24	06			V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1887	04	26	10			V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1887	04	28	08			V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
	BLA	1887	04	28	09			V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1887	04	30	23	45		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1887	08	27	04	30		V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
	BLA	1887	08	27	09	20		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1888	01	12	15	54		V 32.900N	80.000W					3.80 MB BLA		VI		511	F		57
	BLA	1888	01	16	17	52		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1888	02	02	03			V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1888	02	29	11			V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
	BLA	1888	03	03	04	30		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1888	04	16				V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1888	04	16	16			V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1888	04	20				V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1888	05	02				V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1889	08	29	02			V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1890	01	15	11	42		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1891	12	05	22	10		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57

DUP	SOURCE	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	Mb	Ms	MAGNITUDES OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
	BLA	1892	11	03	17	25	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1892	11	04	04	45	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1892	11	04	08	09	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1892	11	06	07	53	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1892	11	08	08	03	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1892	11	08	12	25	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1892	11	10	04	02	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1892	11	10	11	58	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1892	11	11	04	47	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1893	06	21	04	05	V	32.900N	80.000W					3.50 MB BLA		V		511	F		57
	BLA	1893	06	21	09	12	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1893	06	21	09	48	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1893	07	06	09	05	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1893	07	08	07	48	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1893	07	08	15	25	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1893	09	21	05	40	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1893	09	21	07	25	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1893	10	01	01	50	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1893	11	08	04	40	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1893	12	03	16	35	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1893	12	27	06	51	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1894	01	10	09	15	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1894	03	16	19	50	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1894	06	09	10	55	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1894	06	16	01	52	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1894	06	16	02	16	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
	BLA	1894	08	11	17	20	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
	BLA	1990	06	02	02	57	41.5V	32.935N	80.150W	5				2.50 MD SLM		III		511		16	57
	EQH	1907	04	19	08	30	Z	32.9 N	80. W							V		511	F		57
	PDE	1983	11	06	09	02	19.8G	32.937N	80.159W	10G			3.3 GS	3.1 LG GS		V		511	F	13	57
	PDE	1986	09	17	09	33	49.4S	32.928N	80.152W	8				2.60 MD GLD		IV		511	F	5	57
	PDE	1988	01	23	01	57	16.3S	32.935N	80.157W	7			3.30 GS	3.30 MD GLD		V		511	F	19	57
	PDE	1989	01	02	16	35	16.2S	32.936N	80.158W	5				2.60 MD GLD		III		511	F	17	57
	PDE	1989	06	02	05	04	34.0S	32.934N	80.166W	6				2.00 MD GLD		IV		511	F	18	57
	STO	1757	02	07			G	32.9 N	80. W							III		511		G**	57
	STO	1799	04	04			G	32.9 N	80. W							V		511		G**	57
	STO	1799	04	11	08	20	G	32.9 N	80. W							V		511		G*	57
	STO	1817	01	08	09		G	32.9 N	80. W							V		511		G*	57
	STO	1843	02	07	15		G	32.9 N	80. W							III		511		G**	57
	STO	1857	12	19	14	04	G	32.9 N	80. W							V		511		G	57
	STO	1860	12	19			G	32.9 N	80. W							III		511		G**	57
	STO	1876	10				G	32.9 N	80. W							III		511		G**	57
	STO	1876	12	12			G	32.9 N	80. W							IV		511		G**	57
	STO	1886	08	28	08	45	G	32.9 N	80. W							VI		511		G*	57
	STO	1886	08	28	18	20	G	32.9 N	80. W							IV		511		F**	57
	STO	1886	09	01	03	14	G	32.9 N	80. W							III		511		G**	57

DUP	SOURCE	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
	STO	1886	09	01	03	30		G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	01	06	05		G 32.9 N	80. W							VI		511		G**	57
	STO	1886	09	01	07			G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	01	09			G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	01	13	25		G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	01	14			G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	01	14	59		G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	01	18			G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	01	22	15		G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	02	04	55		G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	06	04	15		G 32.9 N	80. W							V		511		G*	57
	STO	1886	09	06	12	30		G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	07	04	15		G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	13	14			G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	20	07			G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	21	09	25		G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	21	10	15		G 32.9 N	80. W							III		511		G**	57
	STO	1886	09	21	10	30		G 32.9 N	80. W							VI		511		G**	57
	STO	1886	09	27	19	02		G 32.9 N	80. W							V		511		G**	57
	STO	1886	09	27	22	02		G 32.9 N	80. W							VI		511		G*	57
	STO	1886	09	28	18			G 32.9 N	80. W							V		511		G*	57
	STO	1886	09	30	19	20		G 32.9 N	80. W							III		511		G**	57
	STO	1886	10	15	09			G 32.9 N	80. W							III		511		G**	57
	STO	1886	10	22	06			G 32.9 N	80. W							III		511		G**	57
	STO	1886	10	22	07	20		G 32.9 N	80. W							III		511		G**	57
	STO	1886	10	22	19	45		G 32.9 N	80. W							III		511		G**	57
	STO	1886	10	23	04	54		G 32.9 N	80. W							VII		511		G	57
	STO	1886	10	30	08	40		G 32.9 N	80. W							III		511		G**	57
	STO	1886	10	31	19	21		G 32.9 N	80. W							III		511		G**	57
	STO	1886	11	07	19			G 32.9 N	80. W							III		511		G**	57
	STO	1886	12	01				G 32.9 N	80. W							III		511		G**	57
	STO	1886	12	02	06	36		G 32.9 N	80. W							III		511		G**	57
	STO	1886	12	02	13			G 32.9 N	80. W							III		511		G**	57
	STO	1887	01	04	11	44		G 32.9 N	80. W							III		511		G**	57
	STO	1887	01	05	13			G 32.9 N	80. W							VI		511		G*	57
	STO	1887	01	11	00	57		G 32.9 N	80. W							III		511		G**	57
	STO	1887	02	26	11			G 32.9 N	80. W							III		511		G**	57
	STO	1887	03	04	07			G 32.9 N	80. W							III		511		G**	57
	STO	1887	03	17	14	09		G 32.9 N	80. W							IV		511		G*	57
	STO	1887	03	19				G 32.9 N	80. W							V		511		G*	57
	STO	1887	03	20				G 32.9 N	80. W							IV		511		G**	57
	STO	1887	03	22				G 32.9 N	80. W							III		511		G**	57
	STO	1887	03	24				G 32.9 N	80. W							III		511		G**	57
	STO	1887	03	30				G 32.9 N	80. W							IV		511		G**	57
	STO	1887	03	31				G 32.9 N	80. W							III		511		G**	57
	STO	1887	04	05	11			G 32.9 N	80. W							III		511		G**	57

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
STO	1887	04	07	04			G 32.9 N	80. W							IV		511		G**	57
STO	1887	04	08	09			G 32.9 N	80. W							IV		511		G**	57
STO	1887	04	09	12			G 32.9 N	80. W							III		511		G**	57
STO	1887	04	10	11	30		G 32.9 N	80. W							IV		511		G**	57
STO	1887	04	14	12			G 32.9 N	80. W							III		511		G**	57
STO	1887	04	16	12			G 32.9 N	80. W							III		511		G**	57
STO	1887	04	18	05			G 32.9 N	80. W							III		511		G**	57
STO	1887	04	23				G 32.9 N	80. W							III		511		G**	57
STO	1887	04	26	04	30		G 32.9 N	80. W							III		511		G**	57
STO	1887	04	30	03	10		G 32.9 N	80. W							III		511		G**	57
STO	1887	05	06				G 32.9 N	80. W							IV		511		G**	57
STO	1887	05	12	03	30		G 32.9 N	80. W							III		511		G**	57
STO	1887	05	12	05			G 32.9 N	80. W							III		511		G**	57
STO	1887	05	14				G 32.9 N	80. W							III		511		G**	57
STO	1887	05	16	12			G 32.9 N	80. W							III		511		G**	57
STO	1887	06	03	12			G 32.9 N	80. W							IV		511		G*	57
STO	1887	06	06				G 32.9 N	80. W							III		511		G**	57
STO	1887	07	10	18			G 32.9 N	80. W							IV		511		G**	57
STO	1887	08	28	03	30		G 32.9 N	80. W							III		511		G**	57
STO	1888	01	12	14	50		G 32.9 N	80. W							III		511		G**	57
STO	1888	01	15	23	40		G 32.9 N	80. W							III		511		G**	57
STO	1888	02	12				G 32.9 N	80. W							III		511		G**	57
STO	1888	03	03				G 32.9 N	80. W							IV		511		G**	57
STO	1888	03	04				G 32.9 N	80. W							IV		511		G**	57
STO	1888	03	14	05			G 32.9 N	80. W							V		511		G**	57
STO	1888	03	20	05			G 32.9 N	80. W							IV		511		G**	57
STO	1888	03	25				G 32.9 N	80. W							IV		511		G**	57
STO	1888	04	20	03			G 32.9 N	80. W							III		511		G**	57
STO	1889	02	10	00	31		G 32.9 N	80. W							IV		511		G**	57
STO	1889	07	12	02	54		G 32.9 N	80. W							IV		511		G**	57
STO	1891	10	13	05	55		G 32.9 N	80. W							IV		511		G**	57
STO	1893	06	24	00	22		G 32.9 N	80. W							III		511		G**	57
STO	1893	07	05	08	10		G 32.9 N	80. W							IV		511		G**	57
STO	1893	09	19	07	05		G 32.9 N	80. W							IV		511		G**	57
STO	1893	09	19	07	40		G 32.9 N	80. W							IV		511		G**	57
STO	1893	09	19	08	55		G 32.9 N	80. W							IV		511		G**	57
STO	1893	09	30	09	05		G 32.9 N	80. W							III		511		G**	57
STO	1893	10	10	01	35		G 32.9 N	80. W							III		511		G**	57
STO	1893	10	24	03	20		G 32.9 N	80. W							III		511		G**	57
STO	1893	11	08	06	05		G 32.9 N	80. W							IV		511		G**	57
STO	1893	12	27	07	17		G 32.9 N	80. W							IV		511		G**	57
STO	1893	12	27	09	09		G 32.9 N	80. W							IV		511		G**	57
STO	1893	12	27	09	56		G 32.9 N	80. W							IV		511		G**	57
STO	1893	12	28	02	20		G 32.9 N	80. W							IV		511		G**	57
STO	1893	12	29	03	46		G 32.9 N	80. W							III		511		G**	57
STO	1894	01	10	08	05		G 32.9 N	80. W							IV		511		G**	57

DUP	SOURCE	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE		LONGITUDE		DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
	STO	1894	01	10	08	49		G 32.9	N	80.	W							IV		511		G**	57
	STO	1894	01	18	06	45		G 32.9	N	80.	W							III		511		G**	57
	STO	1894	01	30	04	05		G 32.9	N	80.	W							IV		511		G**	57
	STO	1894	02	01	05	21		G 32.9	N	80.	W							IV		511		G**	57
	STO	1894	02	14	05	40		G 32.9	N	80.	W							III		511		G**	57
	STO	1894	06	06	11	05		G 32.9	N	80.	W							III		511		G**	57
	STO	1894	08	11	05	10		G 32.9	N	80.	W							III		511		G**	57
	STO	1894	08	14	03	45		G 32.9	N	80.	W							III		511		G**	57
	STO	1894	08	19	04	23		G 32.9	N	80.	W							III		511		G**	57
	STO	1894	08	19	04	46		G 32.9	N	80.	W							III		511		G**	57
	STO	1894	08	20	07	40		G 32.9	N	80.	W							III		511		G**	57
	STO	1894	10	27	07	10		G 32.9	N	80.	W							III		511		G**	57
	STO	1894	12	11	05	27		G 32.9	N	80.	W							IV		511		G**	57
	STO	1894	12	20	09	40		G 32.9	N	80.	W							III		511		G**	57
	STO	1894	12	20	10	50		G 32.9	N	80.	W							III		511		G**	57
	STO	1894	12	29	07	59		G 32.9	N	80.	W							III		511		G**	57
	STO	1895	01	08	05	40		G 32.9	N	80.	W							IV		511		G**	57
	STO	1895	01	08	05	58		G 32.9	N	80.	W							IV		511		G**	57
	STO	1895	01	08	07	29		G 32.9	N	80.	W							IV		511		G**	57
	STO	1895	01	10	08	08		G 32.9	N	80.	W							III		511		G**	57
	STO	1895	02	07	12	53		G 32.9	N	80.	W							III		511		G**	57
	STO	1895	04	07				G 32.9	N	80.	W							III		511		G**	57
	STO	1895	04	27	07	40		G 32.9	N	80.	W							IV		511		G**	57
	STO	1895	05	06	08	50		G 32.9	N	80.	W							III		511		G**	57
	STO	1895	07	25	04	01		G 32.9	N	80.	W							IV		511		G**	57
	STO	1895	08	23	06	43		G 32.9	N	80.	W							III		511		G**	57
	STO	1895	10	06	06	25		G 32.9	N	80.	W							IV		511		G**	57
	STO	1895	10	20	17	08		G 32.9	N	80.	W							IV		511		G**	57
	STO	1895	10	31	11	14		G 32.9	N	80.	W							III		511		G**	57
	STO	1895	11	06	05	10		G 32.9	N	80.	W							III		511		G**	57
	STO	1895	11	12	23	33		G 32.9	N	80.	W							IV		511		G**	57
	STO	1895	11	13	03	11		G 32.9	N	80.	W							III		511		G**	57
	STO	1895	12	03	05	26		G 32.9	N	80.	W							III		511		G**	57
	STO	1895	12	26	06	46		G 32.9	N	80.	W							III		511		G**	57
	STO	1896	03	01	07	50		G 32.9	N	80.	W							III		511		G**	57
	STO	1896	03	19	08	22		G 32.9	N	80.	W							IV		511		G**	57
	STO	1896	05	31	08	09		G 32.9	N	80.	W							III		511		G**	57
	STO	1896	06	29	06	49		G 32.9	N	80.	W							III		511		G**	57
	STO	1896	06	30	05	12		G 32.9	N	80.	W							III		511		G**	57
	STO	1896	08	11	05	58		G 32.9	N	80.	W							IV		511		G**	57
	STO	1896	08	11	06	14		G 32.9	N	80.	W							IV		511		G**	57
	STO	1896	08	11	08	15		G 32.9	N	80.	W							IV		511		G**	57
	STO	1896	08	11	09	24		G 32.9	N	80.	W							IV		511		G**	57
	STO	1896	08	12	07	42		G 32.9	N	80.	W							IV		511		G**	57
	STO	1896	08	13	03	25		G 32.9	N	80.	W							III		511		G**	57
	STO	1896	08	14	05	43		G 32.9	N	80.	W							IV		511		G**	57

DUP	SOURCE	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
	STO	1896	08	15	08	16		G 32.9 N	80. W							III		511		G**	57
	STO	1896	08	16	08	20		G 32.9 N	80. W							III		511		G**	57
	STO	1896	08	17	05	45		G 32.9 N	80. W							III		511		G**	57
	STO	1896	08	30	03	24		G 32.9 N	80. W							IV		511		G**	57
	STO	1896	09	08	13	31		G 32.9 N	80. W							III		511		G**	57
	STO	1896	09	08	18	16		G 32.9 N	80. W							IV		511		G**	57
	STO	1896	09	13	05	20		G 32.9 N	80. W							III		511		G**	57
	STO	1896	11	14	08	15		G 32.9 N	80. W							IV		511		G**	57
	STO	1897	03	17	03	48		G 32.9 N	80. W							III		511		G**	57
	STO	1897	03	30	05	20		G 32.9 N	80. W							III		511		G**	57
	STO	1898	08	03	21	30		G 32.9 N	80. W							III		511		G**	57
	STO	1898	09	23	14	15		G 32.9 N	80. W							III		511		G**	57
	STO	1899	03	10	05	45		G 32.9 N	80. W							IV		511		G**	57
	STO	1899	03	16	13	45		G 32.9 N	80. W							III		511		G**	57
	STO	1899	05	05	10	43		G 32.9 N	80. W							III		511		G**	57
	STO	1899	12	04	12	48		G 32.9 N	80. W							IV		511		G**	57
	STO	1900	01	14	10			G 32.9 N	80. W							III		511		G**	57
	STO	1900	05	10	23	20		G 32.9 N	80. W							III		511		G**	57
	STO	1900	08	11	00	50		G 32.9 N	80. W							III		511		G**	57
	STO	1900	09	04	11	05		G 32.9 N	80. W							III		511		G**	57
	STO	1900	09	24	19	36		G 32.9 N	80. W							III		511		G**	57
	STO	1901	01					G 32.9 N	80. W							III		511		G**	57
	STO	1901	12	02	00	26		G 32.9 N	80. W							IV		511		G**	57
	STO	1902	05	16	03	30		G 32.9 N	80. W							III		511		G**	57
	STO	1902	05	24	14	05		G 32.9 N	80. W							III		511		G**	57
	STO	1903	01	24	01			G 32.9 N	80. W							IV		511		G*	57
	STO	1903	01	29	12	15		G 32.9 N	80. W							III		511		G**	57
	STO	1903	01	31	10	54		G 32.9 N	80. W							IV		511		G**	57
	STO	1903	02	03	10	06		G 32.9 N	80. W							IV		511		G**	57
	STO	1903	05	09	10	49		G 32.9 N	80. W							III		511		G**	57
	STO	1903	08	25	14	56		G 32.9 N	80. W							III		511		G**	57
	STO	1904	09	05	14	53		G 32.9 N	80. W							III		511		G**	57
	STO	1905	03	05	14	15		G 32.9 N	80. W							III		511		G**	57
	STO	1905	06	04				G 32.9 N	80. W							III		511		G**	57
	STO	1905	10	11	18	45		G 32.9 N	80. W							III		511		G**	57
	STO	1906	08	05	06	20		G 32.9 N	80. W							III		511		G**	57
	STO	1908	01	15	19			G 32.9 N	80. W							III		511		G**	57
	STO	1908	10	26	04	10		G 32.9 N	80. W							III		511		G**	57
	STO	1909	02	26	04			G 32.9 N	80. W							III		511		G**	57
	STO	1909	08	21	13	36		G 32.9 N	80. W							III		511		G**	57
	STO	1909	12	14	23			G 32.9 N	80. W							III		511		G**	57
	STO	1910	05	02	09	15		G 32.9 N	80. W							III		511		G**	57
	STO	1910	09	02	07	18		G 32.9 N	80. W							III		511		G**	57
	STO	1910	09	12	18	29		G 32.9 N	80. W							III		511		G**	57
	STO	1912	03	31	20	25		G 32.9 N	80. W							III		511		G**	57
	STO	1912	06	29				G 32.9 N	80. W							III		511		G**	57

DUP	SOURCE	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
	STO	1912	09	29	08	06		G 32.9 N	80. W							IV		511		G**	57
	STO	1912	11	17	12	30		G 32.9 N	80. W							IV		511		G**	57
	STO	1913	03	09	16	30		G 32.9 N	80. W							III		511		G**	57
	STO	1914	06	19	08	13		G 32.9 N	80. W							III		511		G*	57
	STO	1914	07	14	01	53		G 32.9 N	80. W							IV		511		G*	57
	STO	1915	12	13	00	55		G 32.9 N	80. W							III		511		G**	57
	STO	1915	12	20	00	55		G 32.9 N	80. W							III		511		G**	57
	STO	1916	04	30	06	45		G 32.9 N	80. W							III		511		G**	57
	STO	1916	06	25	12	05		G 32.9 N	80. W							III		511		G*	57
	STO	1921	04	19	23	45		G 32.9 N	80. W							III		511		G*	57
	STO	1921	04	23	23	48		G 32.9 N	80. W							III		511		G*	57
	STO	1923	03	24	04	25		G 32.9 N	80. W							III		511		G*	57
	STO	1924	02	14	16	06		G 32.9 N	80. W							III		511		G*	57
	STO	1924	06	03	15	43		G 32.9 N	80. W							III		511		G*	57
	STO	1930	09	03	01	30		G 32.9 N	80. W							III		511		G**	57
	STO	1933	07	26	02	34		G 32.9 N	80. W							III		511		G*	57
	STO	1933	12	19	14	12		G 32.9 N	80. W							IV		511		G*	57
	STO	1933	12	23	09	40		G 32.9 N	80. W							V		511		G**	57
	STO	1933	12	23	09	55		G 32.9 N	80. W							IV		511		G**	57
	STO	1934	12	09	09			G 32.9 N	80. W							IV		511		G*	57
	STO	1935	02	06	12	36		G 32.9 N	80. W							III		511		G**	57
	STO	1935	10	20	16	20		G 32.9 N	80. W							III		511		G**	57
	STO	1940	01	05	08	46		G 32.9 N	80. W							III		511		G**	57
	STO	1940	01	05	13	45		G 32.9 N	80. W							III		511		G**	57
	STO	1943	12	28	14	25		G 32.9 N	80. W							IV		511		G**	57
	STO	1944	01	28	17	30		G 32.9 N	80. W							IV		511		G**	57
	STO	1945	01	30	20	20		G 32.9 N	80. W							IV		511		G**	57
	STO	1945	05	18	12	20		G 32.9 N	80. W							III		511		G**	57
	STO	1945	05	18	12	40		G 32.9 N	80. W							III		511		G**	57
	STO	1946	02	08	18	09		G 32.9 N	80. W							III		511		G**	57
	STO	1947	11	02	04	30		G 32.9 N	80. W							IV		511		G**	57
	STO	1949	02	02	10	52		G 32.9 N	80. W							IV		511		G**	57
	STO	1949	06	27	06	53		G 32.9 N	80. W							IV		511		G**	57
	STO	1951	03	04	02	55		G 32.9 N	80. W							IV		511		G**	57
	STO	1951	12	30	07	55		G 32.9 N	80. W							IV		511		G**	57
	STO	1952	09	27	12	32		G 32.9 N	80. W							III		511		G**	57
	STO	1960	07	24	03	37	30.	G 32.9 N	80. W							V		511		G*	57
	STO	1961	05	20	15	43		G 32.9 N	80. W							III		511		G*	57
	STO	1961	10	18	00	35		G 32.9 N	80. W							III		511		G*	57
	USN	1886	10	22	10			32.9 N	80. W							VI		511		G	57
	USN	1912	06	12	10	30		32.9 N	80. W							VII		511		G	57
	USN	1914	09	22	07	04		33. N	80.3 W							V		511		G	57
1**	BLA	1757	02	07				V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**	BLA	1799	04	04				V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
1**	BLA	1799	04	11	08	20		V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
1**	BLA	1817	01	08	09	00		V 32.900N	80.000W					4.80 CL BLA		V		511			57

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
1**BLA	1843	02	07	15	00		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1860	12	19				V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1876	10					V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1876	12	12				V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1886	08	28	08	45		V 32.900N	80.000W					3.80 MB BLA		VI		511	F		57
1**BLA	1886	08	28	18	20		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1886	09	01	03	14		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	01	03	30		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	01	06	05		V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
1**BLA	1886	09	01	07	00		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	01	09	00		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	01	13	25		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	01	14	00		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	01	14	59		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	01	18	00		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	01	22	15		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	02	04	55		V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
1**BLA	1886	09	06	04	15		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	06	12	30		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	07	04	15		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	13	14	00		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	20	07			V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	21	09	25		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	21	10	15		V 32.900N	80.000W					3.80 MB BLA		VI		511	F		57
1**BLA	1886	09	21	10	30		V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
1**BLA	1886	09	27	19	02		V 32.900N	80.000W					3.80 MB BLA		VI		511	F		57
1**BLA	1886	09	27	22	02		V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
1**BLA	1886	09	28	18	00		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	09	30	19	20		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	10	15	09	00		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	10	22	06			V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	10	22	07	20		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	10	23	04	54		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	10	30	08	40		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	10	31	19	21		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	11	07	19	00		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	12	01				V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	12	02	06	36		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1886	12	02	13	00		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	01	04	11	44		V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
1**BLA	1887	01	05	13			V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	01	11	00	57		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	02	26	11	00		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	03	04	07	00		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1887	03	17	14	09		V 32.900N	80.000W					3.50 MB BLA		V		511	F		57
1**BLA	1887	03	19				V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
1**BLA	1887	03	20			V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	03	22	00		V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	03	24			V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1887	03	30	00		V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	03	31			V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	04	05	11		V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	04	07	04		V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1887	04	08	09		V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1887	04	09	12	00	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	04	10	11	30	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1887	04	14	12	00	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	04	16	12	00	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	04	18	05		V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	04	23			V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	04	26	04	30	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	04	30	03	10	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	05	06			V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1887	05	12	03	30	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	05	12	05		V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	05	14			V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	05	16	12		V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	06	03	12	00	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1887	06	06			V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1887	07	10	18	00	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1887	08	28	03	30	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1888	01	12	14	50	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1888	01	15	23	40	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1888	02	12			V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1888	03	03			V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1888	03	04			V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1888	03	14	05		V	32.900N	80.000W					3.50 MB BLA		V		511	F		57
1**BLA	1888	03	20	05		V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1888	03	25			V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1888	04	20	03		V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1889	02	10	00	31	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1889	07	12	02	54	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1891	10	13	05	55	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1893	06	24	00	22	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1893	07	05	08	10	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1893	09	19	07	05	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1893	09	19	07	40	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1893	09	19	08	55	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1893	09	30	09	05	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1893	10	10	01	35	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1893	10	24	03	20	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1893	11	08	06	05	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
1**BLA	1893	12	27	07	17		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1893	12	27	09	09		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1893	12	27	09	56		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1893	12	28	02	20		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1893	12	29	03	46		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1894	01	10	08	05		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1894	01	10	08	49		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1894	01	18	06	45		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1894	01	30	04	05		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1894	02	01	05	21		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1894	02	14	05	40		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1894	06	06	11	05		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1894	08	11	05	10		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1894	08	14	03	45		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1894	08	19	04	23		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1894	08	19	04	46		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1894	08	20	07	40		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1894	10	27	07	10		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1894	12	11	05	27		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1894	12	20	09	40		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1894	12	20	10	50		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1894	12	29	07	59		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1895	01	08	05	40		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1895	01	08	05	58		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1895	01	08	07	29		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1895	01	10	08	08		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1895	02	07	12	53		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1895	04	07				V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1895	04	27	07	40		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1895	05	06	08	50		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1895	07	25	04	01		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1895	08	23	06	43		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1895	10	06	06	25		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1895	10	20	17	08		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1895	10	31	11	14		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1895	11	06	05	10		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1895	11	12	23	33		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1895	11	13	03	11		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1895	12	03	05	26		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1895	12	26	06	46		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1896	03	01	07	50		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1896	03	19	08	22		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1896	05	31	08	09		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1896	06	29	06	49		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1896	06	30	05	12		V 32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1896	08	11	05	58		V 32.900N	80.000W					3.30 MB BLA		IV		511	F		57

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
1**BLA	1896	08	11	06	14	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1896	08	11	08	15	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1896	08	11	09	24	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1896	08	12	07	42	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1896	08	13	03	25	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1896	08	14	05	43	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1896	08	15	08	16	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1896	08	16	08	20	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1896	08	17	05	45	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1896	08	30	03	24	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1896	09	08	13	31	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1896	09	08	18	16	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1896	09	13	05	20	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1896	11	14	08	15	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1897	03	17	03	48	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1897	03	30	05	20	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1898	08	03	21	30	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1898	09	23	14	15	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1899	03	10	05	45	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1899	03	16	13	45	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1899	05	05	10	43	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1899	12	04	12	48	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1900	01	14	10	00	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1900	05	10	23	20	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1900	08	11	00	50	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1900	09	04	11	05	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1900	09	24	19	36	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1901	01				V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1901	12	02	00	26	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1902	05	16	03	30	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1902	05	24	14	05	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1903	01	24	01		V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1903	01	29	12	15	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1903	01	31	10	54	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1903	02	03	10	06	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1903	05	09	10	49	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1903	08	25	14	56	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1904	09	05	14	53	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1905	03	05	14	15	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1905	06	04	00		V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1905	10	11	18	45	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1906	08	05	06	20	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1908	10	26	04	10	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1909	02	26	04	00	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1909	08	21	13	36	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1909	12	14	23	00	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
1**BLA	1910	05	02	09	15	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1910	09	02	07	18	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1910	09	12	18	29	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1912	03	31	20	25	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1912	06	29			V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1912	09	29	08	06	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1912	11	17	12	30	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1913	03	09	16	30	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1914	06	19	08	13	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1914	07	14	01	53	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1915	12	20	00	55	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1916	04	30	06	45	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1916	06	25	12	05	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1921	04	19	23	45	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1921	04	23	23	48	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1923	03	24	04	25	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1924	02	14	16	06	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1924	06	03	15	43	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1930	09	03	01	30	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1933	12	23	09	40	V	32.900N	80.000W					3.50 MB BLA		V		511	F		57
1**BLA	1933	12	23	09	55	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1934	12	09	09		V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1935	02	06	12	36	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1935	10	20	16	20	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1940	01	05	08	46	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1940	01	05	13	45	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1943	12	28	14	25	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1944	01	28	17	30	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1945	01	30	20	20	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1945	05	18	12	20	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1945	05	18	12	40	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1946	02	08	18	09	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1947	11	02	04	30	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1949	02	02	10	52	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1949	06	27	06	53	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1951	03	04	02	55	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1951	12	30	07	55	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
1**BLA	1952	09	27	12	32	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1961	10	18	00	35	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
1**BLA	1983	11	06	09	02	19.8V	32.937N	80.159W	10				3.30 MD NES		V		511		15	57
1**BLA	1986	09	17	09	33	49.5V	32.931N	80.159W	7				2.60 MD SLM		IV		511		12	57
1**BLA	1988	01	23	01	57	16.4V	32.935N	80.157W	7				3.30 MD SLM		V		511		32	57
1**BLA	1989	01	02	16	35	16.3V	32.936N	80.158W	5				2.60 MD SLM		III		511		32	57
1**BLA	1989	06	02	05	04	34.0V	32.934N	80.166W	6				2.00 MD SLM		IV		511		36	57
1**BLA	1990	06	02	02	57	41.5V	32.935N	80.150W	5	2.50			2.70 DR BLA		III		511			57
1**DNA	1960	07	24	03	37	30.04	32.900N	80.000W	0				4.25 MI EPR				511		0	57

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE		LONGITUDE		DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
1**EQH	1857	12	19	14	04	Z	32.9	N	80.	W							V		511	F		57
1**EQH	1886	10	22	10	20	Z	32.9	N	80.	W							VI		511	F		57
1**EQH	1886	10	22	19	45	Z	32.9	N	80.	W							VII		511	D		57
1**STO	1698	03	05			G	32.9	N	80.	W							III		511		G**	57
1**STO	1754	05	19	16		G	32.9	N	80.	W							III		511		G**	57
1**STO	1799	04	11	19	55	G	32.9	N	80.	W							V		511		G**	57
1**STO	1860	01	19	23		G	32.9	N	80.	W							V		511		G*	57
1**STO	1860	10				G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	06				G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	08	27	06	30	G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	08	27	13	30	G	32.9	N	80.	W							V		511		G*	57
1**STO	1886	08	28	06	30	G	32.9	N	80.	W							III		511		F**	57
1**STO	1886	08	28	09	40	G	32.9	N	80.	W							IV		511		F**	57
1**STO	1886	08	28	19	57	G	32.9	N	80.	W							III		511		F**	57
1**STO	1886	09	01	05	55	G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	09	03	04	53	G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	09	04	04	01	G	32.9	N	80.	W							VI		511		G*	57
1**STO	1886	09	06	04	06	G	32.9	N	80.	W							VI		511		G*	57
1**STO	1886	09	06	16	35	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1886	09	08	17	55	G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	09	09	06	06	G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	09	14			G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	09	17	06	29	G	32.9	N	80.	W							VI		511		G**	57
1**STO	1886	09	20	05		G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	09	21	21	15	G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	09	30	22	10	G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	10	09	03	40	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1886	10	09	05	40	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1886	10	09	06	48	G	32.9	N	80.	W							VI		511		G*	57
1**STO	1886	10	09	18	46	G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	10	15	12	40	G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	10	23	01	07	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1886	10	31	21	46	G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	11	05	17	20	G	32.9	N	80.	W							VI		511		G	57
1**STO	1886	11	28	15	10	G	32.9	N	80.	W							III		511		G**	57
1**STO	1886	11	28	20	13	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1886	12	06			G	32.9	N	80.	W							III		511		G**	57
1**STO	1887	01	03	06	20	G	32.9	N	80.	W							III		511		G**	57
1**STO	1887	03	18	23	10	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1887	03	24	04	05	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1887	03	28			G	32.9	N	80.	W							IV		511		G**	57
1**STO	1887	04	14	07	25	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1887	04	24	06		G	32.9	N	80.	W							III		511		G**	57
1**STO	1887	04	26	10		G	32.9	N	80.	W							IV		511		G**	57
1**STO	1887	04	28	08		G	32.9	N	80.	W							V		511		G**	57
1**STO	1887	04	28	09		G	32.9	N	80.	W							III		511		G**	57

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE		LONGITUDE		DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
1**STO	1887	04	30	23	45	G	32.9	N	80.	W							III		511		G**	57
1**STO	1887	08	27	04	30	G	32.9	N	80.	W							V		511		G**	57
1**STO	1887	08	27	09	20	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1888	01	12	15	54	G	32.9	N	80.	W							VI		511		G**	57
1**STO	1888	01	16	17	52	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1888	02	02	03		G	32.9	N	80.	W							III		511		G**	57
1**STO	1888	02	29	11		G	32.9	N	80.	W							V		511		G**	57
1**STO	1888	03	03	04	30	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1888	04	16			G	32.9	N	80.	W							IV		511		G**	57
1**STO	1888	04	16	16		G	32.9	N	80.	W							III		511		G**	57
1**STO	1888	04	20			G	32.9	N	80.	W							III		511		G**	57
1**STO	1888	05	02			G	32.9	N	80.	W							IV		511		G**	57
1**STO	1889	08	29	02		G	32.9	N	80.	W							III		511		G**	57
1**STO	1890	01	15	11	42	G	32.9	N	80.	W							III		511		G**	57
1**STO	1891	12	05	22	10	G	32.9	N	80.	W							III		511		G**	57
1**STO	1892	11	03	17	25	G	32.9	N	80.	W							III		511		G**	57
1**STO	1892	11	04	04	45	G	32.9	N	80.	W							III		511		G**	57
1**STO	1892	11	04	08	09	G	32.9	N	80.	W							III		511		G**	57
1**STO	1892	11	06	07	53	G	32.9	N	80.	W							III		511		G**	57
1**STO	1892	11	08	08	03	G	32.9	N	80.	W							III		511		G**	57
1**STO	1892	11	08	12	25	G	32.9	N	80.	W							III		511		G**	57
1**STO	1892	11	10	04	02	G	32.9	N	80.	W							III		511		G**	57
1**STO	1892	11	10	11	58	G	32.9	N	80.	W							III		511		G**	57
1**STO	1892	11	11	04	47	G	32.9	N	80.	W							III		511		G**	57
1**STO	1893	06	21	04	05	G	32.9	N	80.	W							V		511		G**	57
1**STO	1893	06	21	09	12	G	32.9	N	80.	W							III		511		G**	57
1**STO	1893	06	21	09	48	G	32.9	N	80.	W							III		511		G**	57
1**STO	1893	07	06	09	05	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1893	07	08	07	48	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1893	07	08	15	25	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1893	09	21	05	40	G	32.9	N	80.	W							III		511		G**	57
1**STO	1893	09	21	07	25	G	32.9	N	80.	W							III		511		G**	57
1**STO	1893	10	01	01	50	G	32.9	N	80.	W							III		511		G**	57
1**STO	1893	11	08	04	40	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1893	12	03	16	35	G	32.9	N	80.	W							III		511		G**	57
1**STO	1893	12	27	06	51	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1894	01	10	09	15	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1894	03	16	19	50	G	32.9	N	80.	W							III		511		G**	57
1**STO	1894	06	09	10	55	G	32.9	N	80.	W							III		511		G**	57
1**STO	1894	06	16	01	52	G	32.9	N	80.	W							III		511		G**	57
1**STO	1894	06	16	02	16	G	32.9	N	80.	W							IV		511		G**	57
1**STO	1894	08	11	17	20	G	32.9	N	80.	W							III		511		G**	57
1**STO	1907	04	19	08	30	G	32.9	N	80.	W							V		511		G	57
1**STO	1912	06	12	10	30	G	32.9	N	80.	W							VII		511		G*	57
1**STO	1952	11	19			G	32.9	N	80.	W							V		511		G*	57
1**USN	1886	09	01	02	51		32.9	N	80.	W							X		511		G	57

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
2**BLA	1857	12	19	14	04	V	32.900N	80.000W					3.50 MB BLA		V		511	F		57
2**BLA	1886	10	22	19	45	V	32.900N	80.000W					4.70 CL BLA		VII		511			57
2**BLA	1908	01	15	19	00	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
2**BLA	1915	12	13	00	55	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
2**BLA	1933	07	26	02	34	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
2**BLA	1933	12	19	14	12	V	32.900N	80.000W					3.30 MB BLA		IV		511	F		57
2**BLA	1952	11	19			V	32.900N	80.000W					3.50 MB BLA		V		511	F		57
2**BLA	1960	07	24	03	37	30.0V	32.900N	80.000W					3.50 MB BLA		V		511	F		57
2**BLA	1961	05	20	15	43	V	32.900N	80.000W					2.70 MB BLA		III		511	F		57
2**BLA	1983	11	06	09	02	19.8V	32.937N	80.159W	9	3.30			3.50 DR BLA		V		511			57
2**BLA	1986	09	17	09	33	49.5V	32.931N	80.159W	6	2.60			3.30 DR BLA		IV		511			57
2**BLA	1988	01	23	01	57	16.4V	32.935N	80.157W	7	3.30			3.50 DR BLA		V		511			57
2**BLA	1989	01	02	16	35	16.3V	32.936N	80.158W	4	2.60			2.70 DR BLA		III		511			57
2**BLA	1989	06	02	05	04	34.0V	32.934N	80.166W	5	2.00			3.30 DR BLA		IV		511			57
2**EQH	1886	11	05	17	20	Z	32.9 N	80. W							VI		511	F		57
2**STO	1886	09	01	02	51	G	32.9 N	80. W							X		511		G	57
2**STO	1886	10	22	10	20	G	32.9 N	80. W							VI		511		G	57
2**STO	1914	09	22	07	04	G	32.9 N	80. W							V		511		G*	57
2**USN	1907	04	19	08	30		32.9 N	80. W							V		511		G	57
3**BLA	1907	04	19	08	30	V	32.900N	80.000W					3.90 CL BLA		V		511			57
3**BLA	1912	06	12	10	30	V	32.900N	80.000W					4.80 CL BLA		VII		511			57
3**BLA	1914	09	22	07	04	V	32.900N	80.000W					4.20 CL BLA		V		511			57
3**DNA	1952	11	19	00	00	00.04	32.900N	80.000W	0				4.25 MI SRA				511		0	57
3**EQH	1886	09	01	02	51	Z	32.9 N	80. W							X	D S	511	C		57
3**USN	1886	10	22	19	45		32.9 N	80. W							VII		511		G	57
4**DNA	1886	09	01	02	51	00.04	32.900N	80.000W	0				6.90 MG NUT				511		0	57
4**DNA	1912	06	12	10	30	00.04	32.900N	80.000W	0				5.25 MI EQH				511		0	57
5**SIG	1886	09	01	02	51	00.0	32.900N	80.000W	0			0.00 SIG			IX		511	D		57
STO	1755	11				G	33.4 N	79.3 W							III		511		H**	58
STO	1820	09	03	08	30	G	33.4 N	79.3 W							IV		511		G**	58
STO	1973	12	19	10	16	08.7G	32.97 N	80.27 W	6				3. SL JLM		III		511		A *	58
1**BLA	1755	11				V	33.400N	79.300W					2.70 MB BLA		III		511	F		58
1**BLA	1820	09	03	08	30	V	33.400N	79.300W					3.30 MB BLA		IV		511	F		58
1**BLA	1973	12	19	10	16	08.7V	32.974N	80.274W	6	3.00			2.70 MB BLA		III		511			58
1**PDE	1971	05	19	12	54	03.4*	33.339N	80.558W	25	3.4					V		511	F	8	58
3**DNA	1974	11	22	05	25	56.74	32.930N	80.160W	6				4.70 MB DNG				511		31	58
4**STO	1974	11	22	05	25	56.7G	32.93 N	80.16 W	6	4.7			4.3 LG GB		VI		511		A	58
5**BLA	1974	11	22	05	25	56.7V	32.926N	80.159W	6	4.70		4.30 BLA	4.59 CL BLA		VI		511			58
USN	1974	11	22	05	25	55.5	32.9 N	80.1 W	18	4.7					VI		511		A	59
6**TEI	1992	08	21	16	32	02.8I	33.656N	80.508W	8				3.80 ML TEI				511		13	59
7**BLA	1992	08	21	16	32	02.8V	33.656N	80.508W	8				3.80 MD TEI				511		13	59
BLA	1990	02	07	07	41	39.9V	32.908N	80.163W	9	2.90			2.70 MD SLM		III		511		29	60
BLA	1990	06	02	17	39	15.3V	32.907N	80.162W	8				1.60 MD SLM		III		511		9	60
STO	1972	02	07	02	46	G	33.46 N	80.58 W					3.2 SL JLM		III		511		D *	60
STO	1972	02	07	02	53	G	33.46 N	80.58 W					3.2 SL JLM		III		511		D *	60
1**BLA	1972	02	07	02	46	V	33.460N	80.580W	0	3.20			2.70 MB BLA		III		511			60

DUP SOURCE	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
1**BLA	1972	02	07	02	53	V	33.460N	80.580W	0	3.20			2.70 MB BLA		III		511			60
1**BLA	1990	02	07	07	41	39.9V	32.908N	80.163W	9	2.70		2.70 BLA	2.90 NU BLA		III		511			60
1**BLA	1990	06	02	17	39	15.3V	32.907N	80.162W	8	1.60			2.70 DR BLA		III		511			60
1**PDE	1974	11	22	05	25	55.5S	32.9 N	80.145W	18	4.7				PDE	VI		511	D	31	60
PDE	1977	12	15	19	16	43.1G	32.923N	80.22 W	9			3. BLA			V		511	F	17	61
USN	1959	08	03	06	08		33. N	79.5 W							VI		511		H	61
1**PDE	1959	08	03	06	08	30.	33. N	79.5 W						USE	VI		511	D		61
2**ROT	1959	08	03	06	08	30.0	33.000N	79.500W	10			5.50 ROT					511			61
3**DNA	1972	02	03	23	11	09.74	33.310N	80.580W	2				4.50 MB DNG				511		30	61
4**STO	1972	02	03	23	11	09.7G	33.31 N	80.58 W	2	4.5			4.5 LG GB		V		511		A	61
5**BLA	1972	02	03	23	11	09.7V	33.306N	80.582W	2	4.50		4.50 BLA	4.09 CL BLA		V		511			61
STO	1929	01	03	12	05	G	33.9 N	80.3 W							IV		511		G *	63
USN	1971	05	19	12	54	03.4	33.3 N	80.6 W	25	3.4					IV		511		A	63
1**BLA	1929	01	03	12	05	V	33.900N	80.300W					3.30 MB BLA		IV		511	F		63
STO	1971	07	31	20	16	55. G	33.34 N	80.63 W	4				3.84 LG BLA		III		511		B	65
1**DNA	1971	07	31	20	16	55.04	33.340N	80.630W	4				4.30 MB EPR				511		9	65
2**BLA	1971	07	31	20	16	55.0V	33.341N	80.631W	4			3.80 BLA	2.70 NU BLA		III		511			65
2**STO	1971	05	19	12	54	03.6G	33.36 N	80.66 W	1	3.4			3.7 LG GB		V		511		B	67
3**DNA	1971	05	19	12	54	03.64	33.360N	80.660W	1				4.10 MB EPR				511		8	67
3**PDE	1971	07	31	20	16	55.6S	33.37 N	80.659W	25						III		511	F	11	67
4**BLA	1971	05	19	12	54	03.6V	33.359N	80.655W	1	3.40		3.70 BLA	3.60 CL BLA		V		511			67
USN	1952	11	19			X	32.8 N	80. W							V		511		H	68
1**USN	1915	12	13	00	55		32.8 N	79.9 W							III		511		G	68
PDE	1977	08	25	04	20	07. G	33.392N	80.692W	10			3.1 BLA			V		511	F	16	70
DNA	1971	08	11	03	50	00.04	33.400N	80.700W	0				3.50 MB BOL				511		0	71
STO	1968	07	12	01	12	G	32.8 N	79.7 W							IV		511		G*	71
STO	1971	08	11			G	33.4 N	80.7 W					3.53 LG BLA				511	F	G*	71
1**BLA	1968	07	12	01	12	V	32.800N	79.700W					3.30 MB BLA		IV		511	F		71
1**BLA	1971	08	11			V	33.400N	80.700W					3.50 NU BLA				511			71
1**STO	1977	08	25	04	20	07.5G	33.369N	80.698W	3				3.1 LG BLA		IV		511		B	71
2**BLA	1977	08	25	04	20	07.5V	33.369N	80.698W	3				2.80 MD SLM		IV		511		13	71
2**DNA	1968	07	12	01	12	00.04	32.800N	79.700W	0				3.75 MI EPR				511		0	71
3**BLA	1977	08	25	04	20	07.5V	33.369N	80.698W	3	3.30		2.80 BLA	3.10 NU BLA		IV		511			71
4**PDE	1967	10	23	09	04	10.1	33.4 N	80.7 W	33	3.8							511		7	71
5**USN	1967	10	23	09	04	10.1	33.4 N	80.7 W	33	3.8					IV		511		A	71
STO	1967	10	23	09	04	02.5G	32.8 N	80.22 W	19	3.8			3.4 LG GB		V		511		B	73
1**DNA	1967	10	23	09	04	02.54	32.800N	80.220W	19				3.80 MB DNG				511		10	73
2**BLA	1967	10	23	09	04	02.5V	32.802N	80.221W	19	3.80		3.50 BLA	3.40 NU BLA		V		511			73
3**ISC	1967	10	23	09	04	03.0	32.790N	80.300W	33			4.30 ISC					511		10	77
USN	1914	03	07	01	20		34.2 N	79.8 W							III		511		G	88
1**STO	1914	03	07	01	20	G	34.2 N	79.8 W							IV		511		F *	88
2**BLA	1914	03	07	01	20	V	34.200N	79.800W					3.30 MB BLA		IV		511	F		88
STO	1914	06	01	04	03	G	32.8 N	80.6 W							III		511		G*	92
1**BLA	1914	06	01	04	03	V	32.800N	80.600W					2.70 MB BLA		III		511	F		92
USN	1960	03	12	12	47	40.	33. N	79. W							V		511		I	98
1**PDE	1960	03	12	12	47	40.	33. N	79. W							V		511	F		98

SOURCE DUP	DATE YR	MO	DY	TIME HR	MN	SEC	LOCATION LATITUDE	LONGITUDE	DEPTH KM	MAGNITUDES Mb	Ms	OTHER	LOCAL	INT MAP	INT MAX	DTSVNWUI	F-E	CE	Q/N	DISTANCE KM
STO	1843	04	11			G	34.2 N	80.6 W							III		511		G**	106
1**BLA	1843	04	11			V	34.200N	80.600W					2.70 MB BLA		III		511	F		106
1**STO	1964	04	20	19	04	44.1G	33.84 N	81.1 W	3				3.5 SL JLM		V		511		B	117
2**BLA	1964	04	20	19	04	44.1V	33.842N	81.096W	3	3.50			3.50 MB BLA		V		511			117
WES	1964	04	20	19	04	N	34.000N	81.000W							V		511			118
3**USN	1964	04	20	19	04	46.	34. N	81. W							V		511		G	118
WES	1959	10	27	02	07	N	34.500N	80.200W							VI		511			123
1**STO	1959	10	27	02	07	28. G	34.5 N	80.2 W							VI		511		G	123
2**USN	1959	10	27	02	07	28.	34.5 N	80.2 W							VI		511		H	123
3**DNA	1959	10	27	02	07	28.04	34.500N	80.200W	0				4.75 MI SRA				511		0	123
4**BLA	1959	10	27	02	07	28.0V	34.500N	80.200W					4.00 CL BLA		VI		511			123
STO	1930	12	26	03		G	34.5 N	80.3 W							IV		511		G *	125
1**BLA	1930	12	26	03		V	34.500N	80.300W					3.30 MB BLA		IV		511	F		125
BLA	1853	05	20			V	34.000N	81.200W					3.80 MB BLA		VI		511	F		133
1**STO	1853	05	20			G	34. N	81.2 W							VI		511		G*	133
PDE	1963	05	04	21	01	35.9	32.2 N	79.7 W	15						IV		511	F	7	136
1**USN	1963	05	04	21	01	36.	32.2 N	79.7 W	15						IV		511		C	136
STO	1972	08	14	15	05	19. G	33.2 N	81.4 W					3. ML ATL		III		511		F**	138
1**BLA	1945	07	26	10	32	16.4V	33.750N	81.376W	5	4.40			4.40 CL BLA		VI		511	F		138
1**BLA	1972	08	14	15	05	19.0V	33.200N	81.400W				3.00 BLA	3.20 ML BLA		III		511			138
STO	1945	07	26	10	32	16.4G	33.75 N	81.38 W	5				4.4 LG DEW		VI		511		B *	139

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13. ABSTRACT *(Maximum 200 words)*

An evaluation of the geological-seismological hazard was conducted at the St. Stephen Powerhouse Project, which is part of the cooper River Rediversion Project in South Carolina. The project is located about 60 km north of Charleston, SC, and consists of a reinforced concrete powerhouse structure founded on rock, flanked by rolled-fill earth embankments, founded partially on rock and partially on alluvium. For the purposes of this study, the alluvium is assumed to be competent, not susceptible to liquefaction. The Maximum Credible Earthquake (MCE) is estimated to correspond to a magnitude 7.5 event, 55 km from the site, resulting in peak ground accelerations at the site of 0.32 and 0.35 g. The Operating Basis Earthquake (OBE) is estimated to correspond to about a magnitude 5 event, resulting in a peak ground acceleration of 0.04 to 0.05 g at the site. The Newmark-sliding-block analyses indicate deformations in the maximum section under the MCE will be negligible, less than 1 cm. However, deformation under retaining walls and embankments founded on natural ground may be on the order of 15 to 35 cm.

14. SUBJECT TERMS

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Embankment dams	Seismic hazard
Maximum Credible Earthquake	

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